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HARRISOCERAS, A NEW STRUCTURAL TYPE OF ORTHOCHOANITIC NAUTILOID

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ABSTRACT—The new genus *Harrisoceras* is proposed for a group of orthochoanitic orthoceracones characterized by a central canal, a large siphuncle, and annulosiphonate deposits, which develop markedly inward. The origin of the genus and the significance of the structural features are discussed. Seven species from the Middle Silurian of America and one from the Middle Silurian of Bohemia belong here.

A CENTRAL canal and annulosiphonate deposits, which develop markedly inward but which do not encroach upon the surface of the connecting ring, have been found in a group of orthochoanitic orthoceracones, for which the new genus *Harrisoceras* is here proposed. The central canal was first noted by Teichert (1933) in the Actinoceroidea, and has not previously been observed outside of that superfamily. There it appears only in portions of phragmocone considerably removed from the living chamber, where the annulosiphonate deposits have developed to such an extent that the only vacant space left in the siphuncle is that formerly occupied by the siphonal vascular system. This consists of a central canal, which extends the length of the siphuncle; radial canals, which radiate from the central canal toward the connecting rings in each segment; and the perispatium, a vacant space lying just within the connecting ring, in which the radial canals terminate. It is due to the perispatium that the deposits of the siphuncle never come to lie in contact with the connecting ring. *Harrisoceras*, though it retains no true perispatium as such, agrees with the Actinoceroidea in the failure of the annulosiphonate deposits to encroach upon the connecting ring. Further, this feature is at variance with the condition found in most orthochoanites.

The remarkable siphonal vascular system characterizes the Actinoceroidea better than any otner feature. It is remarkable to find among orthochoanitic cephalopods a group of forms in which the physiological interrelationship of secreting surfaces and siphonal and cameral tissues is so nearly duplicated. The radial canal system has been made possible in the Actinoceroidea by the development of a vascular system of relatively few large tubes. In most other cephalopods it has been assumed that the tubes of the siphonal vascular system were small and numerous, as in *Nautilus;* certainly they are not calcified in other forms. The central canal of *Harrisoceras* is circular in section, and suggests the calcified wall of a single large tube rather than a grouping of numerous fine tubes, and indicates that in this genus there was an independent specialization paralleling but not equaling that found in the Actinoceroidea.

Not all individuals of a species show a

central canal in *Harrisoceras;* further, in *H. reevesi* Flower, n. sp., the central canal has not yet been observed. However, most specimens are fragmentary, and material for most of the species has been definitely limited. Enough material was available for *H. obstructum* (Newell) to determine the relationship between the appearance of the central canal and other features of the conch. It was found that the central canal

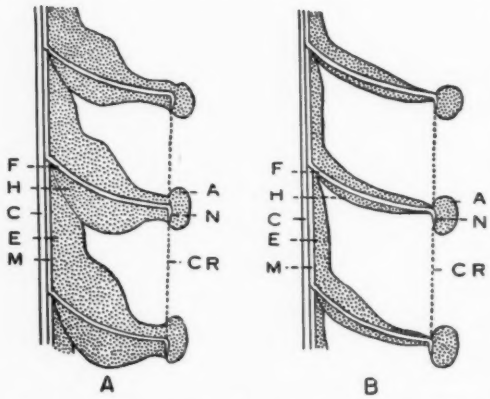

FIG. 1.—Diagrammatic sections showing differences between (A) *Michelinoceras*, in which the secreting surface is continuous, and (B) *Harrisoceras* in which it is discontinuous. *C*, wall of conch; *M*, mural part of septum; *F*, free part of septum; *N*, septal neck; *E*, episeptal deposits; *H*, hyposeptal deposits; *A*, annulosiphonate deposits of siphuncle; *CR*, connecting ring.

did not appear in individuals which lacked the gerontic features of markedly shallow adoral camerae and an internal thickening of the wall of the living chamber. If the calcification of the central canal occurs only in the gerontic stage in other species as well, it is not surprising that it is absent in many specimens which may represent ephebic or pre-ephebic individuals, or that it has not yet been observed in species that are represented as yet by only a few fragmentary specimens.

The interior of *Harrisoceras* suggests the Actinoceroidea in its aspect, and in the field it is not difficult to mistake a *Harrisoceras* for an *Elrodoceras*, a true Actinoceroid with which it is associated. However, there are very real differences which are apparent at once in a polished section. The septal necks of *Elrodoceras* Foerste (1924, p. 228), are recumbent, and those of *Harrisoceras* are straight and parallel to the axis of the conch. It was suspected that *Harrisoceras* might be an orthochoanitic derivative of the Actinoceroidea, for Upper Ordovician forms approach and frequently attain an orthochoanitic condition in the gerontic stage, but the cylindrical condition of the earliest known segments in *Harrisoceras* and the absence of radial canals and perispatium are opposed to such a hypothesis.

Further, *Harrisoceras* may be derived from *Michelinoceras* Foerste (1932, p. 72), by a widening of the siphuncle, a break in the continuous area of secretion of the phragmocone, and an acceleration of the development of siphonal deposits and a retardation of the development of cameral deposits. (Text figure 1.) The calcification of the wall of the central canal remains unique among the orthochoanites, but it is not necessarily indicative of an absence of close relationship with forms lacking this feature. In *Michelinoceras* the earliest annulosiphonate deposits are essentially similar to those of *Harrisoceras*, simple annuli, roughly semicircular in section, and produced as much adapically as adorally. The mature deposit of *Michelinoceras*, however, becomes produced adorally so that it lies against the connecting ring, and its development along the inside of the connecting ring is commensurate with the development of hyposeptal deposits on the outside of the connecting ring (fig. 1A), so that the surface of secretion is continuous from segment to segment. This is certainly as generalized a condition as can be found among orthochoanitic annulosiphonate cephalopods, and it is believed to be primitive. *Harrisoceras* is one of several genetic groups in which the secreting surface has become discontinuous by specialization.

ACKNOWLEDGMENTS

I wish to express my indebtedness to Professor G. D. Harris, of the Paleontological Research Institution, for the loan of cephalopods from Lemonte, Illinois, also to Dr. Carey Croneis and the Walker Museum of the University of Chicago for the loan of the specimen used here as the type of *Harrisoceras rectum* (Worthen).

Professor E. R. Cumings of the University of Indiana has supplied stratigraphic information. Much of the Indiana material studied here was collected on various field trips from Indiana University under the direction and guidance of Professor Cumings. Part of the expense of photography has been met by the Faber publication fund for paleontology of the University of Cincinnati.

SYSTEMATIC DESCRIPTIONS

HARRISOCERAS Flower, n. gen.

Genotype, *Harrisoceras orthoceroides* Flower, n. sp. Waukesha dolomite, Middle Silurian, Lemonte, Illinois.

Conch orthoceraconic, circular or slightly depressed in section. Sutures straight and transverse; septa with normal curvature; camerae deep or moderate; never markedly shallow. Siphuncle normally large in proportion to the diameter of the conch, orthochoanitic, containing annulosiphonate deposits, which take the form of simple annuli. These develop when mature so as to constrict the interior of the siphuncle at the region of the septal foramen to one-third its normal diameter. The deposits develop against the septal necks but never encroach on the surface of the connecting rings. Cameral deposits are episeptal and hyposeptal but are never massive. The mature living chamber shows an internal thickening of the shell before the aperture as in other orthoceracones. The aperture is unknown. The surface is smooth. Thus far not even lines of growth have been detected.

Discussion.—The new genus *Harrisoceras* is widespread in the Middle Silurian but is not known to have a wider stratigraphic range. In Bohemia it is represented by *H. vebrayi* (Barrande) (1876, pl. 210, fig. 1–3).

The known American species are described below. They include the following: *Harrisoceras orthoceroides* Flower, n. sp., Waukesha dolomite, Lemonte, Illinois; *H. rectum* (Worthen), Joliet limestone, Joliet, Illinois; *H. obstructum* (Newell), Liston Creek limestone, Wabash and Yorktown, Indiana; *H. monocameratum* Flower, n. sp., Liston Creek limestone, Wabash and Yorktown, Indiana; *H. reevesi* Flower, n. sp., Laurel limestone, Westport, Indiana; *H. laurelense* Flower, n. sp., Laurel limestone, Harris City, Indiana; and *H. ignotum* Flower, n. sp., Louisville limestone (?) southern Indiana.

It may be noted that the American species thus far recognized are all pre-Racine and are therefore properly placed in the Clinton. In view of the general persistence of genera and frequently species from the Clinton to the Racine fauna, it is suspected that *Harrisoceras* may range upward into the true Niagaran, though thus far its presence in these higher strata has not been recognized.

I have named this interesting genus in honor of Professor G. D. Harris.

KEY TO AMERICAN SPECIES OF HARRISOCERAS

A. Siphuncular segments cylindrical
  B. Adoral diameter of conch less than length of two camerae
    C. Septum one-sixth diameter in depth; diameter equal to length of 1½ camerae ..... *ignotum*
    CC. Septum one-third the diameter in depth; diameter equal length of one camera ..... *monocameratum*
  BB. Adoral diameter greater than length of three camerae.
    D. Diameter equal to length of five camerae; ratio of length to width of siphuncular segments equal 8:7 ..... *reevesi*
    DD. Diameter less than length of four camerae; siphuncle more slender.
      E. Diameter equal to length of 3⅓ camerae; siphuncle diameter one-ninth that of conch ..... *orthoceroides*
      EE. Diameter equal to length of three camerae; siphuncle one-fourth diameter of conch ..... *rectum*
AA. Siphuncular segments faintly convex in outline
  F. Diameter equal to length of four camerae; conch attaining large size ..... *obstructum*
  FF. Diameter equal to length of three camerae; conch small, maximum diameter about 40 mm ..... *laurelense*

HARRISOCERAS ORTHOCEROIDES
Flower, n. sp.
Plate 49, figures 2–4

Conch orthoceraconic, slender, moderate in size. The holotype is a portion of a phragmocone 100 mm in length, of which only the adoral half is figured. The dorsum is missing, and the conch has suffered from pressure directed in a plane slightly oblique to the dorso-ventral plane. The section was apparently originally considerably depressed, with the siphuncle eccentric in the early portion, close to the venter, but becoming subcentral in the later portion. The estimated apical diameters are 25 mm and 30 mm. Here the siphuncle is slightly transverse, 6 mm in dorso-ventral diameter, 6.8 mm in transverse diameter and located 4 mm from the venter. In 45 mm the diameters of the conch increase to 30 mm and 35 mm, while the siphuncle increases to 7 mm, becomes circular in section, and is located 8 mm from the venter. In 50 mm the conch increases to 35 mm and 40 mm, the siphuncle increases to 9 mm and is located 11 mm from the venter.

Sutures straight and transverse. Septa one-fifth the transverse diameter of the conch in depth throughout, being 7 mm where the diameter is 35 mm. Three and one-half camerae occur in a length equal to a transverse adoral diameter except in the gerontic portion. The last four camerae measure 9 mm, 11 mm, 14.5 mm and 13 mm, showing a gerontic contraction in the last, which indicates that the conch did not attain a much larger size than that shown on the type. The siphuncle is cylindrical. Where the segment is 8 mm in diameter it has a length of 15 mm. Necks short, straight, one-ninth the length of the segment. Annulosiphonate deposits constrict the interior of the siphuncle to one-third its diameter. The central canal is preserved in two segments, but is broken and slightly distorted. The camerae contain episeptal deposits and rudimentary hyposeptal deposits. Shell 2.4 mm thick where the diameter of the conch is 38 mm. The surface shows no trace of ornament. Living chamber and aperture unknown.

Discussion.—The contracted condition of the last camera indicates that the species did not attain great size and that the portion of the phragmocone of which the holotype consists was not far removed from the living chamber. The species differs from *Harrisoceras rectum* (Worthen) in the apparently originally depressed section, the much smaller size, the greater depth of the camerae, and the considerably more slender form of the siphuncle. The central canal is well preserved, and its wall is replaced by chalcedony. The annulosiphonate deposits are also outlined in chalcedony, but the centers have been dissolved out, apparently by weathering. The chalcedony in the right side of the siphuncle, as the specimen is oriented in the illustrations, is adventitious. It is not certain whether the peculiar form of the chalcedony band in the next to the last camera represents an abnormal development of the hyposeptal deposits or whether it is adventitious.

Holotype.—Paleontological Research Institution, no. 5814.

Occurrence.—From the Middle Silurian of Lemonte, Illinois, from excavations made for the Chicago drainage canal. The exact horizon is not known, but the lithology of the specimen resembles the Waukesha dolomite.

HARRISOCERAS RECTUM (Worthen)
Plate 49, figures 7, 8

Orthoceras rectum WORTHEN, *1875*, Geol. Surv. Illinois, vol. 6, p. 504, pl. 26, fig. 3.—FOERSTE, *1928*, Denison Univ., Sci. Lab., Bull., vol. 23, p. 243. Not CLARKE and RUEDEMANN, *1903*, New York State Mus., Mem., vol. 5. p. 78, pl. 12, fig. 9.

Original description.—Shell of medium size very gradually tapering, septa moderately concave, two of the intervals being a little less in width than the diameter of the shell. Length of specimen with twelve septa preserved, 8.87 inches; length of outer chamber about 3 inches; surface markings and siphuncle unknown. The shell seems to be nearly related to *Orthoceras crebescens* of Hall, but differs in its much less tapering form and in the proportional width of the septa.

Locality and position: Joliet, Illinois, in the Niagaran limestone of the Upper Silurian.

The type is lost, and as Foerste pointed out, even were it preserved very little could be learned from it, for the siphuncle is not preserved and the conch is slightly flattened by pressure. The diagnostic features are,

however, adequate for the identification of the species, and it seemed advisable to re-establish it upon the basis of a neotype, on which the following description is based:

Revised description.—Conch straight, subcircular in section, the neotype consisting of a portion of a phragmocone 140 mm in length. The apical portion has diameters of 30 mm and 26 mm and is faintly compressed. In 55 mm the section becomes slightly depressed, with diameters of 31 mm and 38 mm. In the next 80 mm depression becomes more marked, resulting in diameters of 28 mm and 43 mm. From this we are forced to conclude that the adoral depression is probably due to flattening, and the conch is probably subcircular or faintly compressed throughout.

Sutures straight and transverse. Septa with a depth of 6 mm where the dorsoventral diameter is 31 mm, or about one-fifth the diameter. Three camerae occupy a length equal to an adoral diameter of 31 mm. Siphuncle central throughout, orthochoanitic, composed of perfectly cylindrical segments. Where the diameter of the conch is 32 mm, the siphuncular segment is 9 mm in diameter and 11 mm in length. Septal necks vertical, less than one-twelfth the length of the segment. Annulosiphonate deposits are well developed in the neotype, but no trace of the central canal remains. Camerae with prominent episeptal deposits and rudimentary hyposeptal deposits. Thickness of shell, surface ornament, aperture and living chamber unknown.

Discussion.—The only point in which the neotype differs from the original description and figure is the very slightly greater depth of the camerae in proportion to the diameter, and the slightly smaller rate of expansion. Both differences are probably due to a slightly greater flattening of the holotype.

Neotype.—University of Chicago, Walker Museum, no. 33399.

Occurrence.—In the Joliet limestone of the Middle Silurian, at Joliet, Illinois.

HARRISOCERAS REEVESI

Flower, n. sp.

Plate 49, figure 6

Conch orthoceraconic, slender, moderate in size. The holotype is slightly depressed, enlarging from 27 mm and 31 mm to 36 mm and 39 mm in a length of 80 mm. The sutures are straight and transverse. There are five camerae in a length equal to the adoral transverse diameter throughout the specimen. The septa are fairly strongly curved, their depth being 9 mm where the transverse diameter of the conch is 32 mm, or nearly one-third the diameter. The siphuncle is large and eccentric. At the apex of the holotype it is 7 mm in diameter and is located 9 mm from the venter and 11 mm from the dorsum. In a length of 39 mm the siphuncle becomes 8 mm in diameter and is placed 8 mm from the venter and 12 mm from the dorsum.

The siphuncle is cylindrical and is composed of rather stout segments. Where the transverse diameter of the conch is 32 mm the siphuncular segment is 8 mm in width and 7 mm in length. The necks are about 0.6 mm in length. Deposits in the siphuncle are typical of the genus. The central canal is not known in this species. The surface, aperture and living chamber are not known.

Discussion.—This species may be recognized readily by the very shallow camerae and the large size of the siphuncle, which is about one-fourth the diameter of the conch.

Type.—Holotype: Indiana University, unnumbered.

Occurrence.—In the Laurel limestone of the Middle Silurian, 2½ miles east of Westport, Decatur County, Indiana.

HARRISOCERAS MONOCAMERATUM

Flower, n. sp.

Plate 49, figure 1

Conch orthoceraconic, slender, increasing throughout at a rate of 1 mm in a length of 10 mm. Section slightly depressed, the holotype expanding from 22 mm and 24 mm to 28 mm and 30 mm in a length of 58 mm. The largest specimen known attains a length of 260 mm and expands from 29 mm to 46 mm. The specimen shows no indication of gerontic contraction of the camerae or of the living chamber. Sutures straight and transverse; septa deep, about one-third the transverse diameter in depth, being 7.5 mm where the transverse diameter is 23 mm. Camerae very deep, one occupying a length equal to a transverse adoral diameter

throughout the known portion of the phragmocone. Siphuncle slightly eccentric throughout, 5 mm in diameter at a point where the transverse diameter of the conch is 24 mm, and separated from dorsum and venter respectively by 12 mm and 5 mm. Siphuncle perfectly cylindrical, with segments nearly five times as long as wide. Necks vertical, less than one-tenth the depth of the camerae, connecting rings straight. Annulosiphonate deposits present only against the septal necks, constricting the interior of the siphuncle to half its original diameter. The central canal has not been observed. Cameral deposits consist of episeptal deposits, developed more against the free part of the septum than against the mural part, and hyposeptal deposits which are rudimentary. Aperture and living chamber unknown.

Discussion.—The very slender form and the deep camerae distinguish this species at once from associated orthoceracones. From *H. ignotum* it can be distinguished by the much smaller diameter of the siphuncle in proportion to the diameter of the conch.

Types.—Holotype: Paleontological Research Institution, no. 5817. Paratypes: Paleontological Research Institution, 5818, University of Indiana 2 sp. unnumbered.

Occurrence.—In the Liston Creek limestone of the Middle Silurian. The types are from the flank rock of a reef exposed in a quarry on the west side of Yorktown, Indiana. Other specimens have been noted at Wabash, Indiana.

Harrisoceras ignotum
Flower, n. sp.
Plate 49, figure 9

Holotype a badly weathered portion of a phragmocone 80 mm in length, containing five camerae. Section probably originally depressed, the transverse diameter increasing from 24 mm to 30 mm in a length of 80 mm. The corresponding adoral dorso-ventral diameter is 26 mm; the adapical dorso-ventral diameter is not known. Sutures straight and transverse. Septum moderately curved, its depth being 5 mm at a transverse diameter of 30 mm. Camerae deep, 1½ in a length equal to an adoral transverse diameter of 30 mm. Siphuncle large, 8.5 mm in diameter at the apical end, 5 mm from the venter. It increases to 8 mm at the adoral end and is 14 mm from the venter, apparently lying dorsad of the center. Septal necks straight and less than one-twelfth the length of the segment. Connecting rings perfectly cylindrical. Where the transverse diameter of the conch is 28 mm the siphuncular segment is 19 mm long and 9 mm wide.

Annulosiphonate deposits well developed; central canal present in apical siphuncular segment of holotype. Camerae with episeptal deposits but without hyposeptal deposits. Living chamber, surface, and aperture are unknown.

Discussion.—This is a typical *Harrisoceras* in structure and can be distinguished from other species by the proportions of camerae and siphuncle. In its very deep camerae it is somewhat similar to *H. monocameratum*, but has slightly shallower camerae and a much larger siphuncle.

Holotype.—Paleontological Research Institution, no. 5815.

Occurrence.—The only data accompanying the specimen is "Devonian of Indiana." The specimen was received in exchange from the New York State Museum, and was originally a part of the material brought together by James Hall. The specimen is badly weathered, and the lithology indicates a light-yellow highly silicious limestone. The fact that the specimen is a typical *Harrisoceras* practically excludes any possibility of its Devonian age. Hall's Devonian material from Indiana came from the southern part of the state, roughly from an area between Louisville, Kentucky, and the Falls of the Ohio, and Lexington, Scott County, Indiana. In this area the Devonian Jeffersonville limestone rests upon the Silurian Louisville limestone. Both are coral facies, not unlike in lithology, and both frequently outcrop together on hillsides. It is not uncommon to find in the soil on hills of the area a mixture of silicified fossils of Devonian and Silurian ages. The badly weathered condition of the specimen suggests strongly that it may have been picked up under such conditions. On the basis of this line of reasoning the specimen is re-

garded as coming from the Louisville limestone of southern Indiana. Other Silurian formations in the region are the Waldron shale, which is excluded as a possibility by lithology, and the Laurel limestone, which is similar enough lithologically to receive serious consideration. The low position of the Laurel is against its being mistaken for Devonian, and further, though persistent collecting has yielded a rich cephalopod fauna, no form has been found at all similar to the species in question.

HARRISOCERAS OBSTRUCTUM (Newell)

Plate 49, figure 5

Orthoceras obstructum NEWELL, *1886*, Boston Soc. Nat. Hist., Proc., vol. 23, pp. 467–8.

Conch orthoceraconic, large, mature individuals attaining a diameter of 55 mm. The section in all specimens is somewhat depressed, but no completely undistorted specimens have been found. The conch expands from 25 mm and 35 mm to 36 mm and 40 mm in a length of 60 mm. The septum is 9 mm in depth at a transverse diameter of 34 mm. Three camerae occur in a length equal to an adoral diameter throughout the less flattened portions. The position of the siphuncle is uncertain owing to the poor preservation. Where the transverse diameter of the conch is 38 mm. the siphuncle is 7 mm in diameter and is 15 mm from one side of the conch and 11 mm from the other. The siphuncular segments are very faintly convex in outline. Where the diameter of the conch is 34 mm, the siphuncular segment is 12.5 mm in length. It expands from 7 mm at the septal foramen to 8.5 mm within the camera. Annulosiphonate deposits are typical of the genus, and a central canal is preserved. Only episeptal deposits are known in the camerae. The surface of the shell is smooth. The proportions of the living chamber and characters of the aperture are unknown.

Discussion.—This is an abundant species in the Liston Creek limestone, but specimens are not usually well enough preserved to show the internal structure. Newell's original figure shows hyposeptal as well as episeptal deposits and represents a more adapically located portion than the hypotype figured, which was selected for the preservation of the central canal.

Types.—The location of Newell's holotype is not known. Hypotypes: Paleontological Research Institution no. 5816; Indiana University, a large series of uncatalogued specimens.

Occurrence.—In the Liston Creek limestone of northern Indiana. Newell's type is from Wabash; the figured hypotype is from Yorktown. Our material included specimens from both localities.

HARRISOCERAS LAURELENSE

Flower, n. sp.

Plate 49, figure 10

The conch is orthoceraconic, slightly depressed in section. In the first 40 mm of the holotype the diameters increase from 27 mm and 29 mm to 32 mm and 34 mm, while in the next 20 mm the conch expands to 32.5 mm and 36 mm, indicating the approach of the gerontic stage. Septum 5 mm in depth throughout a region in which the dorso-ventral diameter varies from 25 mm to 28 mm, that is, between one-fifth and one-sixth the diameter. The siphuncle is 7 mm in diameter throughout, and is 10 mm from the dorsal side of the conch, while varying from 7 mm to 15 mm in 50 mm in its distance from the venter. The sutures are straight and transverse. Four camerae occupy a length equal to the adoral dorso-ventral diameter of the conch.

The segments of the siphuncle are orthochoanitic, but with faintly convex outline. The septal necks are vertical and short. Where the segment is 6 mm in length it expands from 6.3 mm at the septal foramen to 7 mm within the camera. Annulosiphonate deposits are heavy, constricting the interior to less than one-third its diameter, and are slightly more developed orad than apicad of the center of deposition. Obscure traces of a central canal occur in the two apical segments and again in the fourth to the sixth segments. Massive inorganic deposits line the camerae. Episeptal deposits are found on the holotype only on the ventral side. The living chamber and ornament are unknown.

Discussion.—The species agrees with

H. obstructum (Newell) in the faintly convex outline of the siphuncular segments, but is very much smaller, has shallower camerae and a siphuncular segment broader in proportion to its length.

Type.—Holotype: Indiana University, unnumbered.

Occurrence.—In the Laurel limestone of the Middle Silurian. The holotype is from Harris City, Decatur County, Indiana. Other specimens are from Vernin, Jennings County, Indiana.

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EXPLANATION OF PLATE 49

FIGS. *1*—*Harrisoceras monocameratum* Flower, n. sp. Holotype, Liston Creek limestone, Yorktown, Indiana, transverse section, ×0.9 (p. 477)

2–4—*Harrisoceras orthoceroides* Flower, n. sp. Holotype, Waukesha dolomite, Lemonte, Illinois. *2*, Adapical half of holotype, ×0.8; *3*, enlargement showing cameral and siphonal deposits and central canal, ×1.5; *4*, enlargement of second segment from adoral end, showing details of septal necks, deposits and the displaced central canal, about ×2.2. (p. 476)

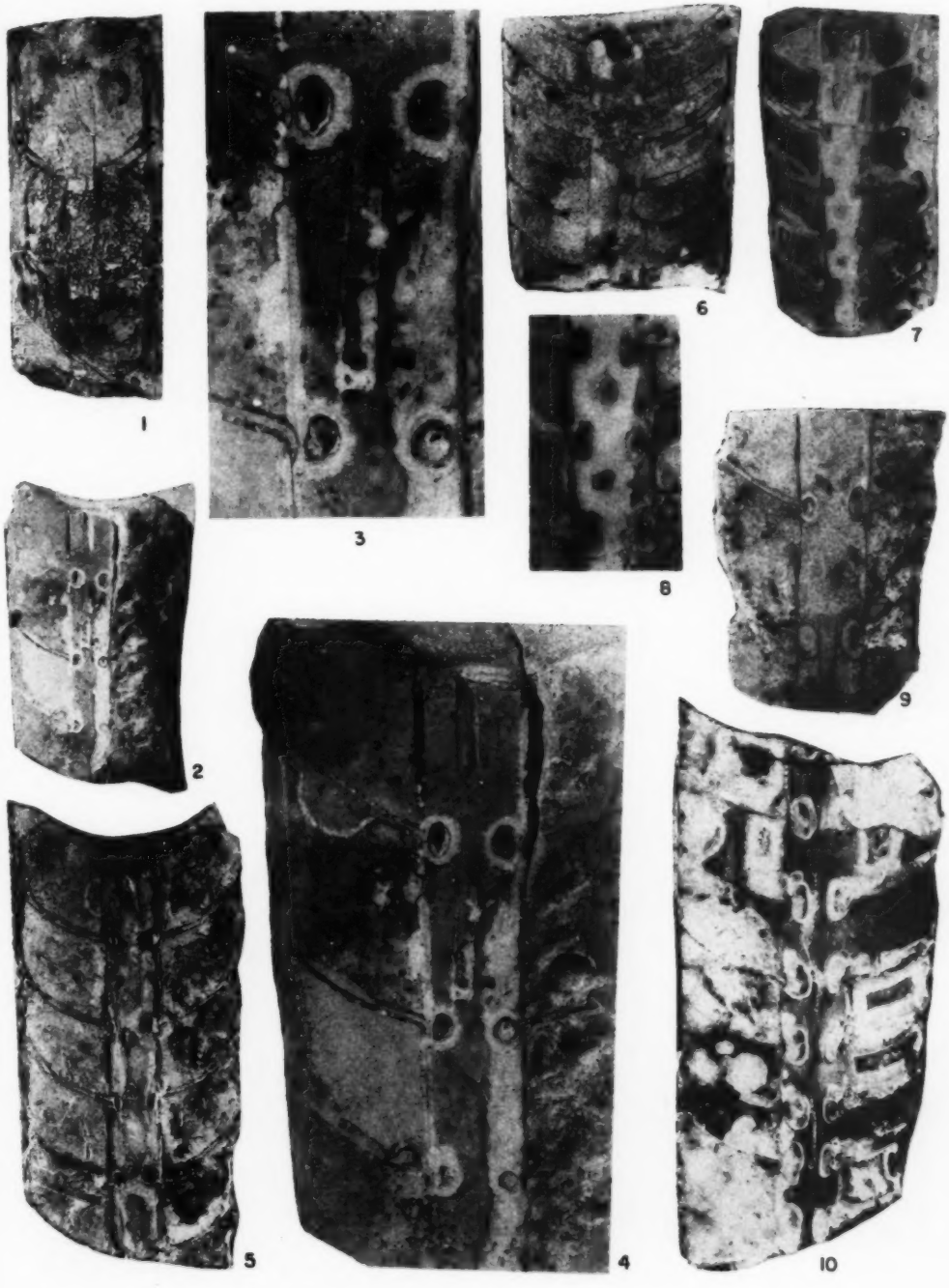
5—*Harrisoceras obstructum* (Newell). Hypotype, Liston Creek limestone, Yorktown, Indiana, transverse section, ×0.75. (p. 479)

6—*Harrisoceras reevesi* Flower, n. sp. Holotype, Laurel limestone, Westport, Indiana, transverse section, ×1. (p. 477)

7–8—*Harrisoceras rectum* (Worthen). Neotype, Joliet limestone, Joliet, Illinois. *7*, Sectioned portion of specimen, ×0.75; *8*, portion of siphuncle, ×1.4. (p. 476)

9—*Harrisoceras ignotum* Flower, n. sp. Holotype, adapical portion, Louisville limestone (?), southern Indiana, transverse section, ×1.2. (p. 478)

10—*Harrisoceras laurelense* Flower, n. sp. Holotype, Laurel limestone, Harris City, Indiana, dorsoventral section ×1.4. (p. 479)



Flower, Species of *Harrisoceras*

Flower, Species of *Troedssonoceras*

JOURNAL OF PALEONTOLOGY, VOL. 13, NO. 5, PP. 481–484, PL. 50, SEPTEMBER, 1939

STRUCTURE AND TAXONOMIC POSITION OF TROEDSSONOCERAS FOERSTE

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ABSTRACT—A restudy of the genotype of *Troedssonoceras* reveals that it is a true actinoceroid, falling in the family Sactoceratidae, and is closely allied to *Deiroceras*. Two Greenland species that have been referred to the genus are not actinoceroids. The generic name *Striatoceras* Shimizu and Obata must be used for them. The genotype of *Troedssonoceras* and two new species are described and illustrated.

THANKS are due to the U. S. National Museum for the loan of material through the courtesy of Dr. Ray S. Bassler and Dr. G. A. Cooper. The Faber publication fund of the University of Cincinnati has defrayed the cost of photographic and other materials.

Troedssonoceras Foerste (1928, p. 40) was based upon *Orthoceras turbidum* Hall and Whitfield (1875 p. 149, pl. 8, fig. 9) of the Upper Ordovician Maysville group of Cincinnati, Ohio. The genus was at that time regarded as unique in combining broad cyrtochoanitic siphuncular segments with shell ornamentation consisting of longitudinal ridges. At the time of the original description of the genus, Foerste placed in it two other species, both from the Cape Calhoun series of northern Greenland, supposedly of Middle Ordovician (Trenton) age. These are *Sactoceras striatum* Troedsson (1926, p. 79, pl. 1, fig. 7; pl. 47, figs. 4–7) and *Sactoceras lineatum* Troedsson (1926, p. 80, pl. 47, figs. 1–3).

Teichert (1934, pp. 40–41, fig. 20) studied the internal structure of the species from Greenland and found that the siphuncles are lined with a continuous lamellar deposit, which was not segmental in origin, and concluded that *Troedssonoceras* did not belong to the Actinoceroidea, and, further, that the only forms known to have similar structure were those included in the Discosouridae Teichert (1931, pp. 1–11). Later Kobayashi (1936, p. 235) proposed the family Troedssonoceratidae to include orthoceracones with a continuous lining in the siphuncle and no cameral deposits, and considered it allied to the Stereoplasmoceratidae, which have similar siphonal deposits but very heavy cameral deposits.

A restudy of Foerste's genotype from the Maysville shows, however, that it possesses annulosiphonate deposits, radial canals and a perispatium, and does belong, therefore, to the Actinoceroidea. The two species from Greenland are not congeneric, and a new generic name is needed. This was provided by Shimizu and Obata (1935, pp. 6–7), who based the name *Striatoceras* on *Sactoceras striatum* Troedsson, apparently in ignorance of Foerste's previous assignment of the species to *Troedssonoceras*. Unfortunately many of the conclusions of Shimizu and Obata arrived at in this paper must be rejected. They referred *Striatoceras* to the new family Ohioceratidae based upon *Ohioceras* Shimizu and Obata (1935, p. 6), which has for its type *Kionoceras myrice* (Hall and Whitfield, 1875, p. 149, pl. 8, fig. 9), of the Cedarville dolomite of Ohio. Foerste (1928a, p. 298, pl. 63, fig. 4; pl. 75,

EXPLANATION OF PLATE 50

FIGS. *1, 2, 7—Troedssonoceras baileyi* Flower, n. sp. Holotype. *1*, ×1; *2*, Apical half, sectioned, ×1½±; *7*, part of the surface of the shell, ×2. (p. 483)

3, 4—Troedssonoceras turbidum (Hall and Whitfield). Hypotype. *3*, Transverse section, ×1½; *4*, internal mold, ×1. (p. 483)

5, 6—Troedssonoceras multiliratum Flower, n. sp. Holotype. *5*, Internal mold, ×1; *6*, transverse section, ×2. (p. 483)

fig. 14) evidently included in this species one in which the siphuncle was orthochoanitic and another in which it was cyrtochoanitic and composed of subspherical segments. The forms can be further differentiated by their proportions. It is not absolutely certain to which the holotype belongs, as its siphuncle is not exposed. The orthochoanitic form has six camerae in a length equal to a diameter; the cyrtochoanitic form has seven and a half camerae in a similar length. The original illustration of *Kionoceras myrice* agrees in proportions with the orthochoanitic species. It therefore appears probable that the description of the Ohioceratidae is not consistent with the actual condition which exists in the genus *Ohioceras* as determined by the condition of the genotype. There is, however, a generic group such as conceived by Shimizu and Obata. Whether it is remotely related to the species from Greenland cannot be determined until the internal structure of its siphuncle is known.

Also, *Sactoceras lineatum* Troedsson was made the type of *Greenlandoceras* Shimizu and Obata (1935, p. 7) and was referred to the new family Greenlandoceratidae. The Ohioceratidae and Greenlandoceratidae are both erected for fluted orthoceracones with cyrtochoanitic siphuncles, though in the Ohioceratidae the siphuncles are "sactoceroid or ormoceroid" in outline, that is, composed of relatively small and narrow segments, and the siphuncles of the Greenlandoceratidae are supposedly "actinoceroid" or composed of broader segments. The difference between the siphuncles of *S. striatum* and *S. lineatum* is not sufficient to justify such a taxonomic procedure. Such differences as exist have to do with the slightly wider siphuncular segments, the slightly longer necks, and the more nearly central siphuncle of *S. lineatum*. Such differences as concern the siphuncular outline alone might be found in different parts of the same species and are inadequate for the distinction of generic or higher groups. Therefore *Greenlandoceras* is regarded as a synonym of *Striatoceras*, which has page priority. It remains to assign the genus to a family. As was shown above, the family Ohioceratidae seems to be based upon a genus which is orthochoanitic rather than cyrtochoanitic, and is probably to be regarded as a synonym of the Kionoceratidae. The proposal of a new generic name to replace *Ohioceras* as conceived by Shimizu and Obata must await more careful study, as must also the proposal of a new specific name for the cyrtochoanitic species included under *Kionoceras myrice*.

The proposal of a new family for the reception of *Striatoceras* is indicated. This name, Striatoceratidae, will replace the name Troedssonoceratidae proposed by Kobayashi. The author is in agreement with Kobayashi in believing that the closest affinities of the family appear to be with the Stereoplasmoceratidae, with which it agrees in the cyrtochoanitic siphuncle and the continuous siphonal deposits, but from which it differs in the complete absence of cameral deposits. As yet no other genera are known which can be placed in the family.

Superfamily ACTINOCEROIDEA Foerste and Teichert

Family SACTOCERATIDAE Troedsson emend. Teichert

TROEDSSONOCERAS Foerste

Conch orthoceraconic, slender. Sutures variable, siphuncle eccentric, composed of fusiform to subglobular segments. The siphonal deposits are typical of the Actinoceroidea. Central and radial canals and perispatium are developed as in *Deiroceras*. Surface of shell ornamented by longitudinal ridges, between which are longitudinal lirae. The ridges increase in number by interpolation, but spacing is fairly constant within the species. Camerae empty. Living chamber not known.

Discussion.—The form of the endosiphuncular structures, illustrated in connection with descriptions given below, show that the genus is a true Actinoceroid.

Tentatively *Troedssonoceras* is regarded as a valid genus. It may be pointed out, however, that the internal structure is not distinguishable from that of *Deiroceras*, and it will be necessary to ascertain the exact nature of the surface of the shell of the genotype of *Deiroceras* before it will be certain

that *Troedssonoceras* is distinct. In the past it has been generally assumed that the exterior of *Deiroceras* is smooth, and smooth-shelled species have been placed in the genus.

TROEDSSONOCERAS TURBIDUM

(Hall and Whitfield)

Plate 50, figure 3–4

Orthoceras turbidum HALL and WHITFIELD, *1875*, Ohio Geol. Surv., vol. 2, pt. 2, Paleontology, p. 100, pl. 3, fig. 1.—JAMES, *1886*, Cincinnati Soc. Nat. Hist., Jour. vol. 8, p. 240.

Troedssonoceras turbidum FOERSTE, *1928*, Denison Univ., Sci. Lab., Bull., vol. 23, p. 41, pl. 6, fig. 2; pl. 23, fig. 9.

Conch orthoceraconic, slender. All specimens known are somewhat distorted. Rate of expansion 2–3 mm in 60 mm. Sutures sloping orad on the dorsum. Septum 4 mm in depth at a diameter of 30 mm, or about half the depth of a camera. Camerae three in a length equal to the adoral diameter in a slightly flattened specimen. Siphuncular segments relatively slender; a segment at a diameter of 25 mm is 10 mm long and increases from 4.5 mm to 9 mm in diameter within the camera. The camerae are empty. Actinoceroid deposits occupy the siphuncle. Radial canals originate at different levels from the central canal on dorsum and venter, as in *Deiroceras*.

The internal mold shows on its surface distant longitudinal ridges with broad faintly concave interspaces. Three to four ridges occupy a width of 10 mm, and four to five in half an inch.

Discussion.—*T. turbidum*, as restricted here, is easily separated from the following by the deeper camerae, the wider spacing of the longitudinal ridges, and the more slender siphuncular segments. Foerste appears to have had both species when he wrote his description. A study of rather long specimens shows that the spacing of the longitudinal ridges remains constant throughout, the ridges probably growing by interpolation.

Type.—Hypotype: Univ. of Cincinnati, no. 3308.

Occurrence.—From the Maysville of Cincinnati, Ohio. Exact locality and horizon not known.

TROEDSSONOCERAS MULTILIRATUM

Flower, n. sp.

Plate 50, figures 5, 6

The type is a sectioned part of a phragmocone. Rate of expansion not known, but certainly very slight, as in the other species of the genus. Sutures straight and transverse. Four and one-half to five camerae occur in a length equal to the adoral diameter of the conch. The septum has a curvature of 4 mm in 30 mm. The siphuncular segments are subspherical. Where the diameter of the conch is 30 mm, the segment is 6 mm long and expands from 6 mm to 8 mm within the camera. The surface of the internal mold preserves the longitudinal ridges of the shell, which are spaced five in 10 mm, or between five and six in half an inch.

Discussion.—The closer spacing of the ornamentation and the more expanded siphuncular segments will distinguish this species from *T. turbidum*, with which it is associated.

Type.—Holotype: Univ. of Cincinnati, no. 22391.

Occurrence.—From the Maysville of Cincinnati, Ohio. Exact locality and horizon unknown.

TROEDSSONOCERAS BAILEYI

Flower, n. sp.

Plate 50, figures 1, 2, 7

Conch orthoceraconic, slender, probably originally very faintly depressed in section. Rate of expansion from 24 mm to 28 mm in a length of 60 mm. Sutures straight, and very slightly inclined orad on the dorsum, although nearly transverse. The septum has a depth of curvature of 4 mm where the diameter is 26 mm. Camerae uniform in depth, four occuring in a length equal to the adoral diameter throughout. Where the dorso-ventral diameter of the conch is 24 mm, the siphuncle is 2 mm in diameter at the septal foramen, and is 4 mm from the venter. The siphuncular segments are fusiform and relatively slender, as in typical *Deiroceras*. A segment 6 mm long expands from 3 mm to 4.5 mm within the camerae. As in *Deiroceras*, the radial canals diverge

from the central canal at different points on the dorsum and venter. Annulosiphonate deposits are advanced in development in the holotype and are typical of the Actinoceroidea in form. The camerae are without any trace of organic deposit.

The ornamentation consists of rounded longitudinal ridges occurring six to seven in a width of 10 mm. The interspaces are occupied by fine longitudinal lirae, which ascend onto the ridges but become faint as they approach the crests and disappear entirely before attaining them. Eight to 12 lirae occur in an interspace. Frequently the middle lirae become elevated, forming incipient weak ridges between the stronger primary ones. The holotype has a length of 146 mm and increases from 24 mm to 30 mm in diameter. The specimen is slightly distorted adorally and has been overgrown by bryozoa, making exact measurements difficult. The sectioned portion is the apical half of the specimen.

Discussion.—The segments of the siphuncle resemble those of *T. turbidum* rather than *T. multiliratum*, but are considerably smaller in proportion to the diameter of the conch than those of either species. Further, the longitudinal ridges are lower and more closely spaced than in the above species.

Type.—Holotype: U. S. National Museum, no. 401S.

Occurrence.—From Nashville, Tennessee, probably from the Trenton.

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FOSSIL LEAVES, FRUITS, AND SEEDS OF CERCIDIPHYLLUM

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ABSTRACT—See Conclusions, p. 497

SOON after I began the critical study of the floras of the Fort Union and related formations in the Rocky Mountain region in 1929 I found myself confronted with the necessity of solving a 70-year old problem. The problem was not only that of determining their closest botanic affinity, but also of finding a satisfactory method for identifying species among the abundant and variable poplarlike leaves commonly, but nearly always doubtfully, referred to *Populus* or to other genera having living species with somewhat comparable leaves. Beginning with the distinguished Swiss paleobotanist, Oswald Heer, who described a number of species, and extending to recent students including E. W. Berry, R. W. Chaney, and A. C. Seward, attention has been called repeatedly to the resemblances between these leaves and those of the living katsura tree, *Cercidiphyllum japonicum* Siebold and Zuccarini, the largest dicotyledonous tree of China and Japan. However, no generic transfers based on these suggestions were made until 1922 when Berry (1922, p. 166) proposed the name *Trochodendroides* for this kind of leaf, intending the term to apply to species of the family Trochodendraceae and not implying specific comparison with the leaves of *Trochodendron*. It is the purpose of this paper to show that not only these fossil leaves, but also characteristic fruits and seeds found associated with them, are more clearly referable to *Cercidiphyllum* than to any other living genus and may be segregated into 5 nominal, recognizable species. It is unnecessary to consider here the somewhat academic botanical problem as to whether *Cercidiphyllum* belongs in the family Trochodendraceae or is monotypic for the Cercidiphyllaceae.

Finding *Cercidiphyllum* postulated on the basis of abundant and variable foliage as being present in American fossil floras, it seemed to me that to confirm this hypothesis it would be necessary to find collateral evidence such as distinctive fruits, seeds, and wood. The first material results of the search I then began appeared in 1934, when I discovered some small, winged seeds in association with leaves, hitherto called *Grewia crenata*, in presumably lower Miocene strata at Republic, Wash. These, together with similar leaves from Bridge Creek and Crooked River, Ore., and a pod, called *Cassia* sp. by Newberry, also from Bridge Creek, were reported as *Cercidiphyllum crenatum* (Unger) Brown in 1935 (Brown, 1935, p. 575).

The anatomical resemblances between the leaves of *Cercidiphyllum crenatum* and those referred to *Trochodendroides* found in earlier formations, then led me to predict that fruits and winged seeds comparable to those of *Cercidiphyllum* would be found if a thorough search were made at the many Cretaceous, Paleocene, and Eocene localities yielding the leaves. My first opportunity to test this prophecy came on July 31, 1936, at Dickinson, N. Dak. One mile south of that town is a clay pit in the Fort Union formation (Paleocene), the locality where F. H. Knowlton and A. C. Peale in 1907 obtained a large collection of leaves. After an hour's digging I was the happy possessor of a dozen small winged seeds of the kind I had predicted (pl. 54, fig. 5). In addition, there were also several striated fruits hitherto called *Leguminosites? arachioides* Lesquereux (pl. 54, fig. 4); but I did not then identify these fruits with the leaves and seeds. This thrilling fulfillment of my prediction was repeated at a number of other Fort Union localities during the remainder of that field season. Later, during the last week of September, I visited the old placer pits

near You Bet, in the western foothills of the Sierras, Nevada County, California. At that locality, in hillocks of clay not eroded by the gold diggers of '49 and subsequent years, occurs a large flora; but the only plants closely resembling the species found at Dickinson, N. Dak., are leaves, fruits, and winged seeds of the kind here under discussion. It suddenly occurred to me then that these three separate organs might be intimately related. To test this probability, upon my return to Washington I reviewed all the Fort Union collections made in 1936 and reexamined all the pertinent collections stored in the National Museum. The result was astonishing in the unanimity with which these collections from many parts of the western United States, Canada, and Alaska yielded small, winged seeds that had never before been detected, or at least, not reported. Most of these localities also yielded the characteristic striated fruits.

Finally, to put to several more deductive field tests the generalization that these leaves, fruits, and seeds may be organically related, I spent 10 days in October and November 1937 exploring the lower Eocene Wilcox deposits in southwestern Tennessee, and in the field season of 1938 I visited a number of localities in the western United States, from all of which leaves and fruits but no seeds had previously been reported. Every locality where I found the matrix suitable for detecting them yielded the small characteristic, more or less delicate, winged seeds. The total number of localities at which I have found all three of the separate organs—leaves, fruits, and seeds—now numbers 30 and is as follows:

1. On Fontanelle Creek, southwestern Wyoming, in Aspen shale (Upper Cretaceous).
2. Marmarth, N. Dak., in Hell Creek formation (Upper Cretaceous).
3. West of Lance Creek, Wyo., at base of Fort Union formation (Paleocene).
4. On Lightning Creek, Wyo., at base of Fort Union formation (Paleocene).
5. On Prairie Dog Creek, east of Ranchester, Wyo, in Fort Union formation (Paleocene).
6. In Union Pacific R.R. cut 1 mile east of Evanston station, Wyo., in Evanston formation (Paleocene).
7. Carneyville, Wyo., in Fort Union formation (Paleocene).
8. Carbon, Wyo., in Fort Union formation (Paleocene).
9. Below mouth of Elk Creek, Yellowstone National Park, Wyo. (Paleocene).
10. In southwestern slope 100 feet below lava cap of South Table Mt., Golden, Colo., in Denver formation (Paleocene).
11. On Second Creek, 10 miles east of Derby, Colo., in Denver formation (Paleocene).
12. At clay pit, 1 mile south of Dickinson, N. Dak., in Fort Union formation (Paleocene).
13. On west side of the Little Missouri River, 2 miles south of Medora, N. Dak., in Fort Union formation (Paleocene).
14. At McCord coal prospect on Cedar Creek, sec. 5, T. 129 N., R. 88 W., N. Dak. (Paleocene).
15. In North Dakota, 3 miles N. of Watauga, S. Dak. (Paleocene).
16. Sec. 1, T. 17 N., R. 7 E., South Dakota (Paleocene).
17. Bluffs on north side of Yellowstone River, at Terry, Mont., in Fort Union formation (Paleocene).
18. Near entrance to canyon of Sweetgrass Creek, east side of the Crazy Mts., Mont., in Fort Union formation (Paleocene).
19. In Northern Pacific R.R. cut ¾ mile south of Wilsall, Mont. (Paleocene).
20. Left bank of Yellowstone River at Burns Ranch, 30 miles northeast of Glendive, Mont., in Fort Union formation (Paleocene).
21. On west side of highway, 1½ miles south of Buckey, Mont., in Fort Union formation (Paleocene).
22. Sec. 29, T. 6 N., R. 16 E., near Melville, Mont. (Paleocene).
23. In bank of Moon Creek, just north of highway, 10 miles west of Miles City, Mont., in Tullock formation (Paleocene).
24. In shales just above coal at Colstrip, Mont., in Fort Union formation (Paleocene).
25. Admiralty Island, Kootznahoo Inlet, Alaska (Tertiary).
26. Steel's Crossing, southeast of Seattle, Wash. (probably upper Eocene).
27. In clays at You Bet, Nevada County, Calif. (probably upper Eocene).
28. North bank of Loosahatchie River, Somerville, Tenn., in Wilcox group (lower Eocene).
29. In Northern Pacific R.R. cut, west side of O'Keefe Creek, 10 miles northwest of Missoula, Mont. (probably Oligocene).
30. In shales on Bridge Creek, 9 miles northwest of Mitchell, Ore. (upper Oligocene or lower Miocene).

From Alaska to Tennessee the field evidence, therefore, appears conclusive that these leaves, fruits, and seeds are organically related. It permits one to predict confident-

ly that in localities where only one of the trio has so far been found the others may be looked for successfully. However, let the prospective collector be forewarned that the seeds are generally not easy to find.

The statement of what appears to me to be a paleobotanical axiom would seem to be apropos at this point in the discussion. Given a basin in which plant remains are accumulating, what parts of land plants are normally most likely to get into the record? The answer, from my experience, is that foliage is first. Nearly all types of deciduous leaves may be blown a considerable distance into streams, lakes, or other basins of deposition. Fruits and seeds, however, with the exception of those that are winged and those growing near the carrier or the basin of deposition, are less likely to get into the fossil record. Therefore, where fruits are present, the same species is most likely to be represented also by leaves if any leaves at all are preserved, although perhaps the leaves may not occur at exactly the same level or the same spot as the fruits. It seems reasonable, therefore, to conclude that when fruits and seeds of deciduous dicotyledons are so prevalent as those here ascribed to *Cercidiphyllum*, their corresponding foliage should be equally, if not more, in evidence. This in general is true for all localities at which I have made collections.

Supplementing the testimony of the field associations, what anatomical or morphological evidence is there for relating these fruits, seeds, and leaves one to another and to *Cercidiphyllum*?

First, the leaves display the same kinds and degrees of variation in form, venation, and marginal dentition, as those of *Cercidiphyllum*. Few, if any, of the fossils cannot be matched by living leaves.

Second, the fruits are capsules or pods like those of *Cercidiphyllum* but differ in being more prominently striated both longitudinally and transversely, and, so far as the early species are concerned, in being borne in racemes not in axillary clusters. A living genus, with fruits that resemble these pods is *Connarus*, of the family Connaraceae, related to the beans and roses. The resemblance, however, upon close scrutiny, proves to be superficial. The exterior striations of *Connarus* fruits are delicate, much forked, closely spaced, and run very obliquely, whereas those of the fossils are generally coarse, little forked, more widely spaced, and run longitudinally or slightly spirally. There is besides in the fossils an underlying second set of striations that runs transversely. The single-seeded pods of *Connarus* are definitely flattened, whereas the fossils are rounded in cross section. Moreover, the leaves of *Connarus* are compound with entire-margined leaflets that have a characteristic venation. At none of the localities where the fossil pods occur have such leaves or leaflets been found, nor have comparable beanlike seeds been recognized. It seems reasonably certain, therefore, that the fossil pods do not represent *Connarus*, and the resemblance must be credited to that list of coincidences with which Nature tests the stability of the faithful.

All the fruits I have found thus far are casts or impressions, some showing the longitudinal striations of the outside layer of the original pods, others the transverse striations of the next underlying layer. Consequently, I have no direct proof of winged seeds within the pods, as in living *Cercidiphyllum*. However, in their discussion of one of these fruits, *Jenkinsella apocynoides*, Reid and Chandler (1933, p. 482) report what may be seeds lying transversely within the locule, and suggest that if these be seeds, they are "linear, with the length transverse to the length of the fruit, and lie one above the other in the locule . . . "

Third, the winged seeds vary in size directly as the size of the pods with which they are associated in the collections. At You Bet, Calif., the pods are small, and the seeds are comparative dwarfs (pl. 55, figs. 3, 4, 5). At Evanston, Wyo., the pods are large, and the seeds are giants (pl. 54, figs. 14, 15). At other localities pods of intermediate size are associated with seeds in proportional dimensions. This is as it should be, for when a small, determinate number of seeds must be packed snugly in a receptacle having limited space, as, for example, in the Leguminosae and Meliaceae, the size of the seeds will tend to vary with the size of the locules. Thus, large and small beans may be found in different pods on the same bean plant; and in fossil and living species of *Cedrela* it has been my experience that the

variation in size and shape of the winged seeds is fully as great as that displayed by both the fossil and living species of *Cercidiphyllum*. If, therefore, this fact of concomitant variation is correctly interpreted, and there being, so far as I am aware, no other comparable fossil pods in the same collections suitable for having contained the winged seeds, it is strongly suggestive, if not conclusive, that the winged seeds were produced in the striated pods.

Fourth, in America no fossil wood has yet been definitely identified as that of *Cercidiphyllum*. In East Greenland, however, woods described as *Tetracentronites hartzi* and *Corylopsites groenlandicus* (Mathiesen, 1932, pp. 5, 16) and said to be very similar to that of *Cercidiphyllum japonicum* were found in strata that at other localities yielded the typical leaves of *Trochodendroides*. Wood anatomists are generally agreed that the wood of the Trochodendraceae and Cercidiphyllaceae is primitive (Bailey, 1924, p. 442). This fact, accordingly, has indirect value as indicating that species of Cercidiphyllaceae could have been present at the same time as the earliest occurrences of these leaves, fruits, and seeds.

The field and morphologic evidence, therefore, seems harmonious in the conclusion that there is an intimate relationship between the leaves, fruits, and seeds here associated. Unless all the signs fail, or unless I have misinterpreted the evidence, the family Cercidiphyllaceae appears to be the natural group to which the fossils belong. Among the identifiable plant remains from all the localities where this trio is found I find no suggestion of any other genus or family that meets the same combination of requirements. Because the term *Trochodendroides* has served its purpose and because, in the light of the new evidence from the fruits and seeds here reported, it now poses the botanic difficulty of showing when and where *Trochodendroides* becomes *Cercidiphyllum*, I propose that the term be displaced by *Cercidiphyllum*. This procedure will also avoid the ambiguous and confusing connotations that may be inferred by supposing that *Trochodendroides* is like *Trochodendron*. It may be argued that some other generic name than *Cercidiphyllum* is justified because of small differences in leaf structure and considerable difference in habit of fruiting displayed by the early species; nevertheless, the relation between the early species and living *Cercidiphyllum* seems to me to be of the same order as that of the racemed wild black cherry (*Prunus serotina*) to the fascicled sweet cherry (*Prunus avium*), or of the racemed box elder maple (*Acer negundo*) to the fascicled silver maple (*Acer saccharinum*), although the members of both couplets, I am fully aware, are sometimes referred to different genera.

Seeds.—The fossil winged seeds here reported differ greatly in size and shape, and superficially resemble the small seeds of some conifers. In general they are crescent-shaped, but many are scythe-shaped, the elliptic seed portion corresponding to the handle, and the delicate wing to the blade of a short scythe or sickle. The overall length of the smallest seeds I have found is 2 mm, the largest 15 mm (pl. 54, fig. 15). Unfortunately, I have been unable to detect sufficient morphologic differences in these seeds to warrant separation of the species on the basis of seeds alone. The seed portion of the seed of *Cercidiphyllum japonicum* is perceptibly angular rather than smoothly elliptic, as seems to be the case in most of the fossils.

Fruits.—The fossil fruits, except in the later species where they are relatively smooth, are striated, somewhat blunt-pointed pods, which, like the seeds, also differ greatly in size and shape, the smallest being 8 mm and the largest 35 mm long. The fruits, at least in the early species, were borne in racemes, the individuals being indiscriminately alternate and opposite in the same raceme. The pods from You Bet, Calif., have elongated, slightly curling tips (pl. 55,

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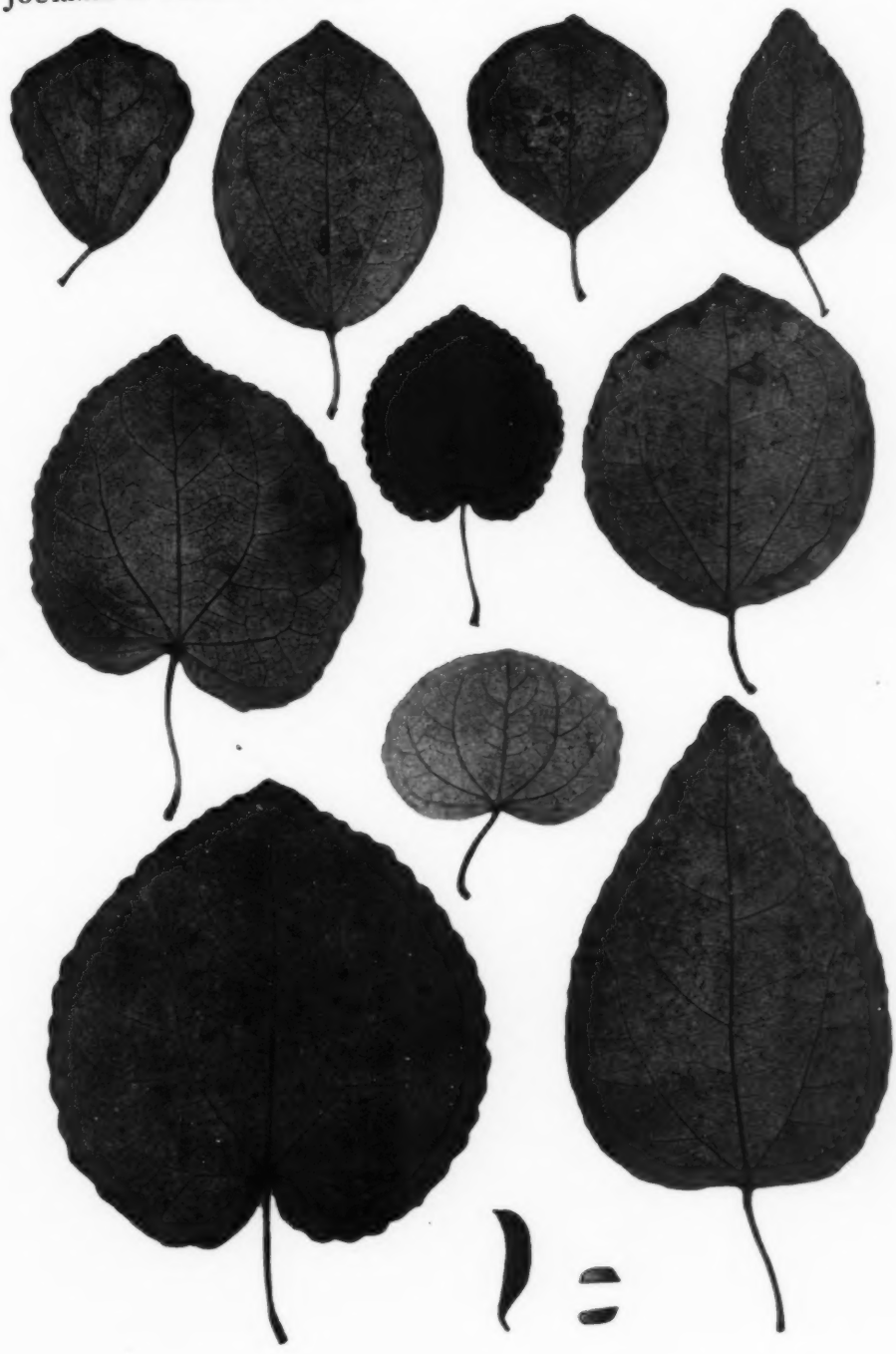
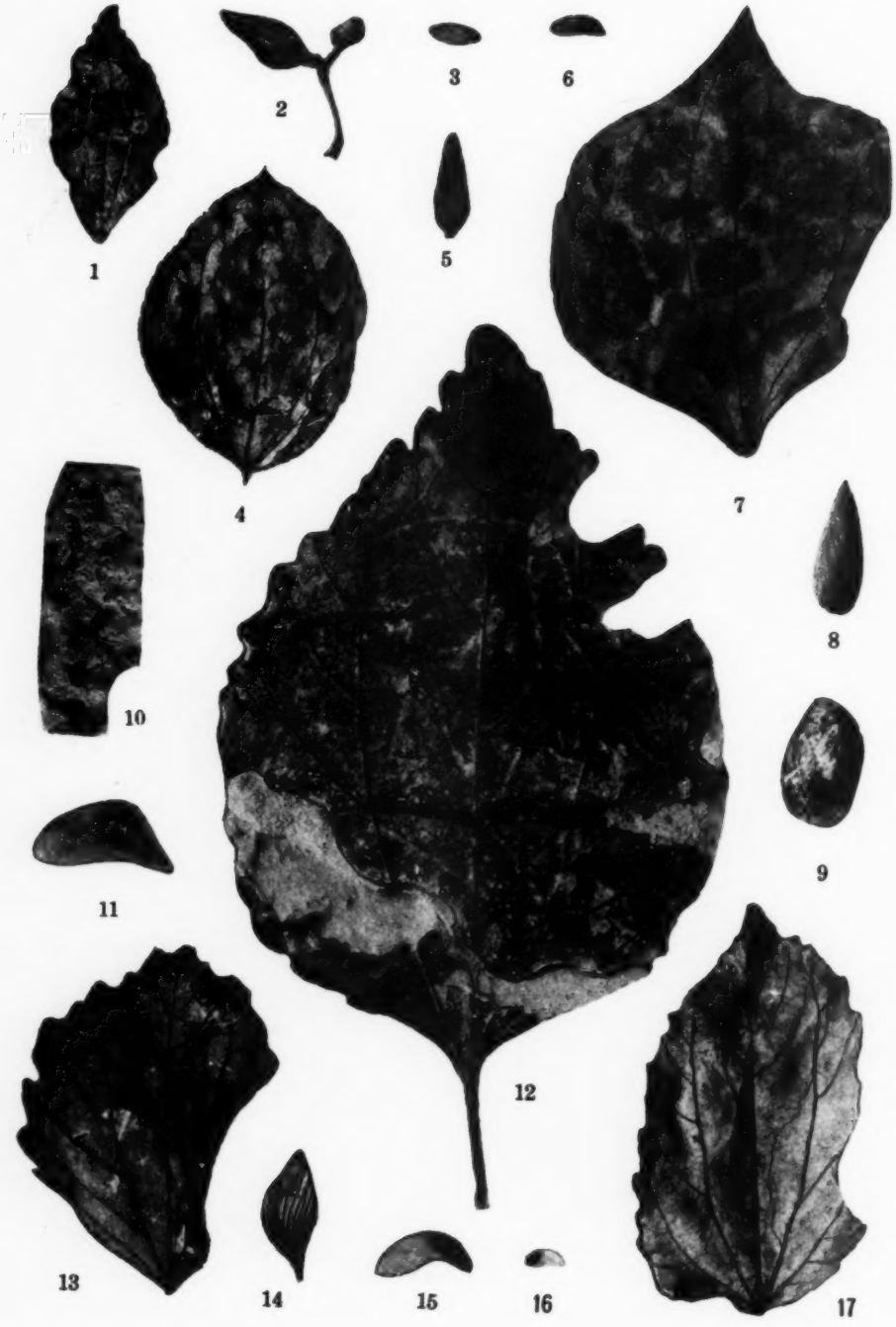
EXPLANATION OF PLATE 51

Leaves, fruit, and seeds of the katsura tree, *Cercidiphyllum japonicum* Siebold and Zuccarini, of eastern Asia, ×1. The leaves are from a tree growing on the grounds of the National Academy of Sciences, Washington, D. C. In the lower right-hand leaf the first strong secondary vein rises from the midrib at an extremely low level for these leaves. (p. 490)



Brown, *Cercidiphyllum japonicum*



Brown, *Cercidiphyllum ellipticum*

fig. 4), which arouses the suspicion that this species may have been a vine. In cross-section these fruits are irregularly rounded. The substance of the pod was tough and was traversed by two sets of fibers or strands, so that some casts show only the impression of the outer set of longitudinal, slightly spiral strands, some only the transverse inner set, and some the two sets superimposed. The hinge line may sometimes display small round cross sections of fibers (pl. 54, fig. 12). Inasmuch as all the pods I have collected are casts or impressions, there are none that contain seeds, the pods evidently having dehisced and released their contents before falling from the tree, shrub, or vine, as the case may have been, and becoming entombed. These pods, like the seeds, except in the later species, are so much like one another morphologically that I cannot detect sufficient constant differences to distinguish species on this basis alone.

Leaves.—The leaves of this group, as the voluminous literature shows, have proved to be extremely confusing, so that not only have many species been described, but inevitably the species, at least so far as names are concerned, have become almost inextricably mixed. Can this confusion be resolved? I believe it can, and I submit a solution based upon perhaps the largest suite in existence. Anticipating that it may be roundly condemned I nevertheless venture to present the following list of species and their synonymies, with a key to their separation. To understand this key and its practical application to an "unknown" collection, one should first consider the reasons for the confusion existing in the group.

The earlier workers apparently did not recognize the characters that distinguish these leaves from those of *Populus*, and somewhat similar leaves of other genera. Although these leaves differ greatly in outline, their internal architecture is fundamentally the same in that all, except perhaps some seedling leaves and a few others, have a palmate venation; and the primary characteristics of that venation are: ***The midrib is usually flanked by two, or, in most well-developed leaves, by three pairs of primary basal veins***, whose outer branches, as well as those of the secondaries, form loops and, except in the early species, do not enter marginal teeth; and ***the first strong secondary vein comes off from the midrib at a point above the middle, or at least, well above the widest portion of the leaf.*** This statement applies to normal mature leaves; but there are occasional, abnormal exceptions, including for example, those extremely obovate specimens in which a line across the widest portion of the leaf cuts the midrib well above the midpoint between the top of the petiole and the apex; and the first secondaries may come off from the midrib below that point. Teeth, when present, are usually gland-tipped, rounded, rounded-dentate, rounded-crenate, or crenate; but it should be emphasized that teeth alone are not satisfactory for distinguishing this group from *Populus* and other genera.

The venation of *Populus*, to take only one of the genera with which these leaves have been confused, is in general fundamentally pinnate, but in a few species, as for example, *P. tremuloides* and *P. balsamifera* and their varieties, a strong tendency toward palmateness is present. In those *Populus* leaves having a palmate venation, the number of pairs of primary basal veins is usually 1, sometimes 2, but may occasionally be 3 in

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EXPLANATION OF PLATE 52

Leaves, fruits, and seeds of *Cercidiphyllum ellipticum* (Newberry) Brown. (p. 491)

FIGS. *1–3*—From Aspen shale (Upper Cretaceous) on Fontanelle Creek, southwestern Wyoming. *3*, ×3.

4—From Colgate member of Fox Hills sandstone (Upper Cretaceous), southwest of Glendive, Mont., ×1.

5, *6*—From Hell Creek formation (Upper Cretaceous) at Marmarth, N. Dak. *6*, ×2.

7, *8*—From Dakota sandstone (Upper Cretaceous), Ulm, Minn., and Delphos, Kans., respectively, ×1.

9—From Judith River formation (Upper Cretaceous), Judith, Mont., ×2.

10, *12*—From Tullock formation (Paleocene), 9 miles west of Miles City, Mont., ×1.

11, *13–17*—From McCord coal prospect (Paleocene) on Cedar Creek, N. Dak. *11*, *15*, ×3.

balsamifera and its varieties. Some leaves of most species of *Populus* display a pair of well-developed glands at the base of the blade and top of the petiole. There should be little likelihood, therefore, of confusing *Populus* and *Cercidiphyllum*, provided the fossils are well enough preserved to be tested by the foregoing distinguishing characters. However, Oliver (1939, pp. 563–568), discussing atavistic leaf forms of various species of trees, compares the leaves of the living *Populus tremuloides* with those of the fossils, *P. arctica*, *P. amblyrhyncha*, *P. cuneata*, and *P. oxyrhyncha*, after accepting these fossils as true *Populus*. Reference to her plate on page 566 shows clearly that the leaves of *P. tremuloides* (figs. 9–13) differ from the fossils (figs. 8–12) in having only one pair of primary basal veins as contrasted with two pairs in the fossils. The latter are examples of *Cercidiphyllum arcticum*.

Before the fossil species of *Cercidiphyllum* can be designated some satisfactory method for disposing of all variants must be devised, because these variants comprise many of the numerous species that now clutter up the floral lists to the consternation and dismay of the student. An alternative to the practice of describing species upon the slightest pretext is to lump indiscriminately. Needless to say, both methods are distasteful, unsatisfactory, and constitute an evasion of responsibility, however easy they may seem to make the difficulties of identification.

A solution to this problem may perhaps be found by considering the leaf variants (Plate 51) displayed by *Cercidiphyllum japonicum*, all of which are from a small tree on the grounds of the National Academy of Sciences in Washington, D. C. It would seem to me that the lower left hand symmetric, cordate leaf with rounded-crenate teeth displays all the distinguishing leaf characters of the species to best advantage and may be called the norm of the species. Immediately above this leaf is another, similar in most respects to the first, but markedly asymmetric. In the lower right hand corner is a deltoid leaf, the base of which is horizontal, with scarcely any suggestion of cordateness. Above are elliptic or obovate leaves with rounded or cuneate bases. When this series of variants is compared with that shown by the sequence from the Cretaceous onward of all the specimens here assumed to belong to *Cercidiphyllum*, a striking parallelism can be seen. The earliest Cretaceous leaves of this kind were elliptic in outline, with rounded or cuneate bases. Late in the Cretaceous or early in the Tertiary deltoid forms appeared, which reached their culmination in numbers and perfection of outline in the late Paleocene or early Eocene. Elongate forms with cordate bases appeared in the latter half of the Eocene and lasted through most of the Oligocene. Some time during the Oligocene the asymmetric, heart-shaped forms reached their best development, and probably out of these, late in the Miocene, the present species became differentiated. The conclusion seems irresistible that the living species, may, through atavistic reversion, display some of the leaf forms evolved in the course of its history. Furthermore, it would seem possible to add an important corollary to this generalization: At any stage in its history a given species may exhibit all the variations of its immediate antecedents, but will reveal few hints of the further variations that are destined to be developed by its descendants. Thus, associated with the deltoid forms characteristic of the Paleocene and earlier half of the Eocene, are elliptic forms similar to those that were characteristic of the Cretaceous; but there are only a few scattered occurrences that presage the well-developed, cordate, asymmetric forms that were to flourish in the Oligocene and Miocene.

In view of these apparent facts I have constructed a leaf key for the segregation of the nominal fossil species of *Cercidiphyllum* based upon what I choose to call a leaf norm. This is the leaf that displays all the fundamental characters of the species—size, outline, venation, marginal dentition, etc.,—in their best and most constant occurrence. The selection of such norms, especially for fossil species, is doubtless somewhat arbitrary and subject to personal predilections. It is quite probable that a fossil norm may include, with its variants, more than one actual species; but the evil consequences of that possibility, so far as the solution of stratigraphic problems is con-

cerned, are likely to be negligible as compared with the neutralizing and confusing effect created by having too many poorly defined and inseparable species. The norms of *Cercidiphyllum*, like those of *Ginkgo*, clearly mark the development of the genus in its later history.

One disadvantage of this leaf norm method needs to be emphasized: A large suite of material is generally necessary to identify an "unknown" norm; and, as some variants are common to nearly all the species, it is quite likely that, when these alone are present in a collection, they may not be a clue to the true species.

In the synonymy of each species I have accepted only the most convincing specimens, and have included only those citations showing figures or those having a bearing on the nomenclature and distribution of the species. Obviously it would require far too much space to discuss the details and reasons for each item of the synonymies. Such discussion is, therefore, restricted largely to those items whose inclusion would otherwise seem recondite.

All figured specimens are in the U. S. National Museum, except plate 56, figure 15, which is in Peabody Museum, Yale University.

KEY TO THE FOSSIL SPECIES OF CERCIDIPHYLLUM

Leaves generally symmetric

Margins entire

Leaves round, elliptic, obovate, etc., with rounded or cuneate bases and long petioles. These, together with those having similar outlines and more or less marginal dentition, probably occur in all species of *Cercidiphyllum*.

Margins toothed

Leaf norm elliptic to broad-ovate-elliptic, with rounded or cuneate base and long petiole; most veins undulating or angular, sometimes with branches running into coarse dentate, rounded teeth.

C. ellipticum (Newberry) Brown (p. 491)

Leaf norm deltoid, with tendency to elongate apex, incipient cordate base, and petiole of medium length; branches of veins forming loops within the margin; teeth medium-sized, regular, rounded-dentate to crenate.

C. arcticum (Heer) Brown (p. 492)

Leaf norm elongate, broad-lanceolate, with cordate base, and short petiole; teeth regular, rounded-dentate to crenate.

C. elongatum Brown (p. 494)

Leaves generally more or less asymmetric

Leaf norm cordate, slightly elongate, asymmetric, short-petioled; teeth regular, crenate.

C. crenatum (Unger) Brown (p. 496)

Leaf norm similar to the preceding but shorter in proportion to width and more symmetric.

C. japonicum Siebold and Zuccarini (p. 496)

DESCRIPTION OF SPECIES

CERCIDIPHYLLUM ELLIPTICUM (Newberry) Brown, n. comb.

Plate 52, figures 1–17; plate 54, figures 8, 9–11, 14–16

Populus elliptica NEWBERRY, *1868*, p. 16.—*1898*, p. 43, pl. 3, figs. 1, 2.—HOLLICK, *1930*, p. 63, pl. 31, fig. 5.

Ficus? rhomboideus LESQUEREUX, *1868*, p. 96.

Populus microphylla NEWBERRY, *1868*, p. 17.—*1898*, p. 46, pl. 3, fig. 5. [This specimen after cleaning shows numerous small teeth instead of the large teeth as illustrated.]

Phyllites rhomboideus LESQUEREUX, *1874*, p. 112. pl. 6, fig. 8.

Populus arctica HEER, *1878*, vol. 5, pt. 4, p. 26, pl. 2, fig. 1b.—KRYSHTOFOVICH, *1918*, p. 48, text fig. 7.—ENDO, *1925*, p. 68, pl. 17, figs. 12, 17.

Populus glandulifera Heer. HEER, *1878*, vol. 5, pt. 4, p. 25, pl. 3, fig. 4.

Populus protozadachii DAWSON, *1883*, p. 26, pl. 7, fig. 25.

Populus sp. KNOWLTON, *1905*, p. 140, pl. 19, fig. 1.

Zizyphus lamarensis BERRY, *1912*, p. 398, pl. 31, fig. 1;—*1922*, p. 170, pl. 36, fig. 4.

Smilax? coloradensis KNOWLTON, *1918*, p. 85, pl. 33, fig. 1. [This specimen after cleaning shows rounded teeth near the apex.]

Macclintockia sachalinensis KRYSHTOFOVICH. *1918*, p. 61, text fig. 15.

Trochodendroides rhomboideus (Lesquereux) BERRY, *1922*, p. 116, pl. 36, fig. 5.

Populus pseudoelliptica HOLLICK, *1930*, p. 63, pl. 31, fig. 6.

Populus pseudostygia HOLLICK, *1930*, p. 63, pl. 31, fig. 7.

Macclintockia electilis HOLLICK, *1930*, p. 74, pl. 31, fig. 4.

Nymphaeites exemplaris HOLLICK, *1930*, p. 75, pl. 40, fig. 4.

Grewia alaskana HOLLICK, *1930*, p. 107, pl. 82, fig. 1.

Zizyphus pseudomeeki HOLLICK, *1930*, p. 103, pl. 29, fig. 6b; pl. 79, fig. 3.

Zizyphus varietas HOLLICK, *1930*, p. 103, pl. 78, figs. 6, 7a.

Zizyphus electilis HOLLICK, *1930*, p. 103, pl. 79, fig. 7.

Zizyphus abnormalis HOLLICK, *1930*, p. 103, pl. 79, fig. 8.

Paliurus minimus KNOWLTON, *1899*, p. 759, pl. 77, figs. 7–9.

Paliurus visibilis HOLLICK, *1930*, p. 102, pl. 79, fig. 4.

Paliurus pseudopinsonensis HOLLICK, *1930*, p. 102, pl. 79, figs. 5, 6.
Populus? aspensis BROWN, *1933*, p. 5, text fig. 1.
Trochodendroides nebrascensis (Newberry) DORF, *1938*, p. 61, pl. 11, figs. 1, 4, 6, 7. See synonymy. Add the following ten items from KNOWLTON, *1930:*
Piper heeri Lesquereux. KNOWLTON, *1930*, p. 43, pl. 11, fig. 6.
Populus? sp. KNOWLTON, *1930*, p. 57, pl. 21, fig. 9.
Populus lacoeana KNOWLTON, *1930*, p. 60, pl. 22, fig. 5.
Populus richardsoni Heer. KNOWLTON, *1930*, p. 62, pl. 23, fig. 6. [Not fig. 8, which is *Cissus lobato-crenata* Lesquereux.]
Populus zeilleri (Lesquereux) KNOWLTON, *1930*, p. 54, pl. 18, fig. 8; pl. 19, figs. 1–3.
Cercis coloradensis KNOWLTON, *1930*, p. 99, pl. 45, fig. 5.
Zizyphus hesperius KNOWLTON, *1930*, p. 111, pl. 49, fig. 2.
Cissus obovata KNOWLTON, *1930*, p. 114, pl. 49, fig. 5.
Pterospermites grandidentata Lesquereux. KNOWLTON, *1930*, p. 118, pl. 50, fig. 6; pl. 51, fig. 3.
Viburnum? heterodontum KNOWLTON, *1930*, p. 127, pl. 55, fig. 2.

FRUITS ASSOCIATED WITH C. ELLIPTICUM

Sabalites? fructifer LESQUEREUX, *1878a*, p. 114, pl. 11, figs. 3, 3a.
Leguminosites? arachioides LESQUEREUX, *1878a*, p. 301, pl. 59, fig. 14.
Cycadeospermum lineatum LESQUEREUX, *1892*, p. 30, pl. 1, fig. 14.
Nyssa denveriana KNOWLTON, *1919*, p. 412.
Nyssa? racemosa KNOWLTON, *1919*, p. 413.
Berrya racemosa KNOWLTON, *1930*, p. 134, pl. 41, figs. 4, 5.
Carpites lakesii KNOWLTON, *1922*, p. 165, pl. 19, fig. 8. [Fig. 8 is from Scranton, Colo.; other figures of doubtful identity.]
Carpolithus spp. 2, 3. BERRY, *1922*, p. 180, pl. 40, figs. 1–3. [Not fig. 4, which is a fern fragment.]
Leguminosites arachioides minor BERRY [part], *1935*, p. 64. See synonymy.—DORF [part], *1938*, p. 64, pl. 11, figs. 2, 3, 5. See synonymy.
Trochodendroides sp. BROWN, *1939*, p. 249, pl. 48, figs. 19–22.
Trochodendroides sp. BROWN, *1939*, p. 249, pl. 48, fig. 23.

In the earliest occurrences the leaves of this species are generally elliptic, but the latest forms tend to be broad-elliptic to ovate in outline. The teeth vary from small and crenate to large, coarse, rounded-dentate, in which case they may receive prominent vein branches. All have rounded or cuneate bases. The fruits and seeds are small to large, the largest being those from Evanston, Wyo. (pl. 54, figs. 14, 15).

Range.—This species ranges from the lowest upper Cretaceous into the Paleocene, where in some cases its distinction from *C. arcticum* may be difficult to determine. The geographic range appears to be from Texas to Alaska, and thence to eastern Siberia and probably to Greenland.

Typical figures.—NEWBERRY, *1898*, pl. 3, figs. 1, 2; pl. 27, figs. 4, 5.—KNOWLTON, *1930*, pl. 41, figs. 4, 5.—DORF, *1938*, pl. 11, figs. 3, 7.

CERCIDIPHYLLUM ARCTICUM (Heer) Brown, n. comb.

Plate 3; plate 54, figures 1–7, 12, 13, 17; plate 56, figures 1–6a, 10, 11

Populus arctica HEER, *1866*, p. 275.—*1868*, vol. 1, pp. 100, 137, pl. 4, figs. 6a, 7; pl. 5; pl. 6, figs. 5, 6; pl. 8, figs. 5, 6; pl. 17, figs. 5b, c; pl. 19, fig. 7b; pl. 21, figs. 14, 15a; pl. 48, fig. 2b.—*1869*, vol. 2, no. 4, p. 468, pl. 43, fig. 14; pl. 52, fig. 8b; pl. 53, fig. 4b.—*1870*, vol. 2, no. 3, p. 55, pl. 10, figs. 2–7; pl. 11, fig. 1; pl. 12, fig. 6c.—*1874*, vol. 3, no. 3, p. 15, pl. 2, fig. 20a; pl. 3, fig. 9.—*1876*, vol. 4, no. 1, p. 69, pl. 31, fig. 2.—*1878*, vol. 5, no. 1, p. 30, pl. 5, fig. 1a.—*1878*, vol. 5, no. 2, p. 49, pl. 15, figs. 3–5.—*1880*, vol. 6, pt. 1, no. 2, p. 9, pl. 4, fig. 1.—*1880*, vol. 6, pt. 1, no. 3, p. 13, pl. 1, fig. 2c; pl. 2, figs. 6, 7.—*1883*, vol. 7, p. 74, pl. 67, figs. 2, 2b, 3; pl. 96, fig. 1.—LESQUEREUX, *1878a*, p. 178, pl. 23, figs. 1–6.—DAWSON, *1890*, p. 71, pl. 10, figs. 2–4.—SCHMALHAUSEN, *1890*, p. 15, pl. 1, fig. 26.—PENHALLOW, *1908*, p. 76.—MATHIESEN, *1932*, p. 59, text fig. 23.—HOLLICK, *1936*, p. 60, pl. 22, fig. 5a; pl. 23, figs. 1, 2; pl. 24, figs. 1–3; pl. 27, fig. 4; pl. 117, figs. 4–8; pl. 118, fig. 5.
Populus flabellum NEWBERRY, *1863*, p. 524.—*1898*, p. 44, pl. 20, fig. 4.
Populus genetrix NEWBERRY, *1868*, p. 64.—*1898*, p. 44, pl. 27, fig. 1.—PENHALLOW, *1908*, p. 77.—HOLLICK, *1936*, p. 63, pl. 26, fig. 5.
Populus hookeri HEER, *1868*, vol. 1, p. 137, pl. 21, fig. 16.—*1876*, vol. 4, no. 1, p. 69, pl. 14, fig. 5.—DAWSON, *1890*, p. 71, pl. 10, fig. 5.
Populus curvidens HEER, *1876*, vol. 4, no. 1, p. 68, pl. 28, figs. 4, 5.
Populus retusa HEER, *1876*, vol. 4, no. 1, p. 69, pl. 14, figs. 6, 7.
Populus richardsoni HEER, *1868*, vol. 1, p. 98, pl. 4, figs. 1–5, 6b; pl. 6, figs. 7, 8; pl. 15, fig. 1c.—*1870*, vol. 2, no. 3, p. 54, pl. 10, figs. 8–11 [not fig. 12].—*1871*, vol. 2, no. 4, p. 468, pl. 44, figs. 7–9a.—*1876*, vol. 4, no. 1, p. 68, pl. 32, figs. 1, 2.—*1878*, vol. 5, no. 2, p. 49, pl. 15, fig. 7.—*1880*, vol. 6, pt. 1, no. 3, p. 13, pl. 1, figs. 2d, 3.—*1883*, vol. 7, p. 73, pl. 66, fig. 1.—WARD, *1887*, p. 23, pl. 8, fig. 6.—SCHMALHAUSEN, *1890*, p. 14, pl. 1, figs. 23–25.—HOLLICK, *1936*, p. 61, pl. 27, figs. 1–3; pl. 28, fig. 2; pl. 29, figs. 1–3; pl. 33, fig. 1a.
Populus sclerophylla Saporta. HEER, *1868*, vol. 1, p. 99, pl. 7, fig. 5.

Populus zaddachi HEER, *1868*, vol. 1, p. 98, pl. 6, fig. 3 [not other figs.].—*1871*, vol. 2, no. 3, p. 55, pl. 2, fig. 13c; pl. 10, fig. 1.—*1871*, vol. 2, no. 4, p. 468, pl. 43, fig. 15a; pl. 44, fig. 6.—*1876*, vol. 4, no. 1, p. 68, pl. 12, figs. 2b, 5b; pl. 28, fig. 3.—*1878*, vol. 5, no. 1, p. 31, pl. 8, fig. 6.—*1878*, vol. 5, no. 3, p. 25, pl. 4, figs. 1–3; pl. 15, figs. 3a, b.—*1883*, vol. 7, p. 74, pl. 88, fig. 1.—LESQUEREUX, *1878a*, p. 176, pl. 22, fig. 13.—HOLLICK, *1936*, p. 69, pl. 24, figs. 4, 5; pl. 116, figs. 5, 6.

Populus decipiens LESQUEREUX, *1878a*, p. 179, pl. 23, figs. 7–11.

Populus glandulifera Heer. LESQUEREUX, *1883*, p. 226, pl. 46A, figs. 3, 4.—WARD, *1887*, p. 19, pl. 4, figs. 1–4.—KNOWLTON, *1899*, p. 694, pl. 84, fig. 1.

Populus daphnogenoides WARD, *1887*, p. 20, pl. 7, figs. 4–6.—DAWSON, *1891*, p. 83, text fig. 13.—KNOWLTON, *1899*, p. 696, pl. 84, fig. 2.

Populus hederoides WARD, *1887*, p. 22, pl. 8, fig. 5.

Populus oxyrhyncha WARD, *1887*, p. 21, pl. 8, figs. 1, 2.

Populus obtrita DAWSON, *1890*, p. 82, text fig. 12.

Populus newberryi COCKERELL, *1925* [part]. For *P. acerifolia* NEWBERRY, *1898*, p. 37, pl. 28, fig. 7.

Populus smilacifolia Newberry. KNOWLTON, *1919*, p. 496.

Populus wilmattae COCKERELL, *1925*, p. 3, pl. 2, fig. 8.

Populus amblyrhyncha Ward. HOLLICK, *1936*, p. 63, pl. 25, fig. 5a; pl. 28, fig. 1; pl. 30, fig. 4a; pl. 116, fig. 7.

Populus flexuosa HOLLICK, *1936*, p. 63, pl. 30, fig. 5; pl. 33, fig. 2; pl. 117, fig. 9.

Populus latior Braun. HOLLICK, *1936*, p. 64, pl. 26, figs. 1, 2. [Not figs. 3, 4.]

Populus obscura HOLLICK, *1936*, p. 68, pl. 27, figs. 5, 6.

Populus speciosa Ward. HOLLICK, *1936*, p. 62, pl. 31, fig. 2.

Smilax reticulata HOLLICK, *1936*, p. 58, pl. 22, fig. 1.

Ficus? grönlandica HEER, *1869*, vol. 2, no. 4, p. 472, pl. 54, fig. 2.

Hakea? arctica HEER, *1868*, vol. 1, p. 113, pl. 15, figs. 5, 6.

Hedera macclurii HEER, *1868*, vol. 1, pp. 119, 138, pl. 17, figs. 1a, 2c, 3, 5a; pl. 21, fig. 17a.—*1869*, vol. 2, no. 4, p. 476, pl. 52, fig. 8c.—HOLLICK, *1936*, p. 156, pl. 98, figs. 1–3.

Hedera minima WARD, *1887*, p. 57, pl. 26, fig. 5.

Boehmeria antiqua GARDNER, *1887*, p. 291, pl. 15, fig. 1.

Macclintockia chignikensis HOLLICK, *1936*, p. 112 pl. 25, fig. 5b.

Grewia crenata (Unger) Heer. WARD, *1887*, p. 85, pl. 39, fig. 1.—BERRY, *1935*, p. 50.

Grewia obovata Heer. WARD, *1887*, p. 88, pl. 39, figs. 6, 7.

Grewia zizyphoides HOLLICK, *1936*, p. 147, pl. 84, fig. 2.

Grewiopsis tennesseensis BERRY, *1916*, p. 285, pl. 64, figs. 4, 5.—*1930b*, p. 106, pls. 15, 16.

Grewiopsis wyomingensis BERRY, *1930c*, p. 73, pl. 8, fig. 6. [Probably not other figures.]

Grewiopsis mclearni BERRY, *1935*, p. 50, pl. 12, fig. 3; pl. 14A.

Cercis wilcoxiana BERRY, *1916*, p. 228, pl. 49, fig. 1.—*1930b*, p. 84.

Paliurus colombi HEER, *1868*, vol. 1, p. 122, pl. 17, fig. 2d; pl. 19, figs. 2–4.—*1869*, vol. 2, no. 4, p. 482, pl. 50, fig. 18.—*1878*, vol. 5, no. 4, p. 52, pl. 13, figs. 1–3.—*1883*, vol. 7, p. 131, pl. 69, fig. 9; pl. 84, fig. 12; pl. 97, fig. 8.—LESQUEREUX, *1878a*, p. 273, pl. 50, figs. 13–17.—WARD, *1887*, p. 75, pl. 33, figs. 8–10.—KNOWLTON, *1899*, p. 740, pl. 101, fig. 7.—BERRY, *1935*, p. 46.—HOLLICK, *1936*, p. 141, pl. 115, figs. 5–7.

Paliurus pealii WARD, *1887*, p. 76, pl. 33, figs. 12–14.

Paliurus pulcherrimus WARD, *1887*, p. 75, pl. 33, fig. 11.—BERRY, *1935*, p. 47, pl. 11, figs. 5–8.

Paliurus ceterus HOLLICK, *1936*, p. 141, pl. 79, figs. 7, 8.

Zizyphus cinnamomoides Lesquereux. WARD, *1887*, p. 74, pl. 33, fig. 7.

Zizyphus hyperboreus HEER, *1868*, vol. 1, p. 123, pl. 49, figs. 2, 2b.—*1869*, vol. 2, no. 4, p. 482, pl. 50, fig. 20.—*1883*, vol. 7, p. 130, pl. 67, fig. 6.—LESQUEREUX, *1878a*, p. 276, pl. 51, fig. 15.—HOLLICK, *1936*, p. 140, pl. 79, figs. 5, 6.

Zizyphus meekii LESQUEREUX, *1878a*, p. 275, pl. 51, figs. 10–14.—WARD, *1887*, p. 74, pl. 33, figs. 5, 6.

Zizyphus serrulatus WARD, *1887*, p. 73, pl. 33, figs. 3, 4.—KNOWLTON, *1899*, p. 740, pl. 101, figs. 4, 5.

Zizyphus meigsii (Lesquereux) Schimper. KNOWLTON, *1917*, p. 336, pl. 99, figs. 1, 2; pl. 100, fig. 3 [but not Lesquereux and Berry references].—HOLLICK, *1936*, p. 140, pl. 31, fig. 3a; pl. 79, fig. 4.

Trochodendroides arctica (Heer) BERRY, *1926*, p. 109. pl. 13, figs. 1–4.—SEWARD and CONWAY, *1935*, p. 15, text fig. 3, pl. 3, figs. 22, 23; pl. 4, fig. 30; pl. 5, fig. 39.

Trochodendroides cuneata (Newberry) BERRY, *1930*, p. 20, pl. 5, figs. 2, 3. See synonymy. Add the following emendations:—LESQUEREUX, *1883*, p. 225, pl. 46A, fig. 5.—WARD, *1887*, p. 19, pl. 4, figs. 5–8; pl. 5, figs. 1–3.—NEWBERRY, *1898*, p. 41, pl. 28, figs. 2–4; pl. 29, fig. 7.

Trochodendroides genetrix (Newberry) BROWN, *1935*, p. 577, pl. 68, fig. 4.

Trochodendroides speciosa (Ward) BERRY, *1930a*, p. 22, pl. 5, fig. 8. See synonymy.

Trochodendroides sp. BERRY, *1930a*, p. 22.

Dicotylophyllum washingtonense (Knowlton) SEWARD and CONWAY, *1935*, p. 32, text figs. 17, 18; pl. 5, fig. 36.

FRUITS AND SEEDS ASSOCIATED WITH C. ARCTICUM

Nyssa arctica HEER, *1869*, vol. 2, no. 4, p. 477, pl. 43, fig. 12c; pl. 50, figs. 5–7.—*1876*, vol. 4, no. 1, p. 80, pl. 19, figs. 1–9.—*1883*, vol. 7, p. 117, pl. 83, fig. 6; pl. 91, fig. 7.

Nyssa reticulata HEER, *1876*, vol. 4, no. 1, p. 81, pl. 29, figs. 3, 4.

Carpolithus follicularis HEER, *1869*, idem, p. 484, pl. 50, figs. 14, 15.

Nyssidium ekmani HEER, *1870*, vol. 2, no. 3, p. 62, pl. 15, figs. 1–7.—*1883*, vol. 7, p. 118, pl. 92, fig. 8.—HOLLICK, *1936*, p. 159, pl. 30, fig. 4b; pl. 120, figs. 8–12.
Nyssidium crassum HEER, *1870*, vol. 2, no. 3, p. 62, pl. 15, figs. 8–14.
Nyssidium oblongum HEER, idem, p. 63, pl. 15, figs. 15–20.
Nyssidium fusiforme HEER, idem, p. 63, pl. 15, fig. 24.
Nyssidium lanceolatum HEER, idem, p. 63, pl. 15, figs. 21–23.
Nyssidium grönlandicum HEER, *1874*, vol. 3, no. 4, p. 12, pl. 2, figs. 18, 19.
Leguminosites? arachioides Lesquereux. WARD, *1887*, p. 65, pl. 29, fig. 2.—PENHALLOW, *1908*, p. 61, text fig. 14.—BERRY, *1916*, p. 249, pl. 48, fig. 9.—KNOWLTON, *1917*, p. 326.
Nyssidium spicatum SCHMALHAUSEN, *1890*, p. 16, pl. 1, figs. 27–29.
Nyssidium geminatum SCHMALHAUSEN, *1890*, p. 16, pl. 1, figs. 30, 30a.
Picea pinifructus BROWN, *1929*, p. 282, pl. 70, fig. 5.
Leguminosites arachioides minor BERRY, *1930b*, p. 89, pl. 14, figs. 2–6.—[part] *1935*, p. 64.
Jenkinsella apocynoides REID and CHANDLER, *1933*, p. 481, pl. 28, figs. 1–5.
Fruit of *Viburnum?* sp. HOLLICK, *1936*, p. 168, pl. 107, figs. 8, 9.

The leaf norm of this species is deltoid, with slightly elongate apex and a base that is almost a horizontal line, but may show incipient cordateness. The teeth are generally regular, rounded-crenate. The fruits and seeds differ little from those of *C. ellipticum* and this, together with the fact that elliptic leaves are exceedingly abundant in *arcticum* may create confusion of the two species where they overlap or *ellipticum* becomes transitional into *arcticum*. Such overlapping is probably the case in the floras described by Heer from the northern circumpolar regions.

The leaf called *Dicotylophyllum washingtonense* (Knowlton) by Seward and Conway can be matched with large, entire-margined specimens of *C. arcticum* from the Fort Union formation at Burns Ranch, Montana. These leaves, however, are not identical with those called *Ficus? washingtonensis* Knowlton from the Latah formation at Spokane, Wash., as intimated by Seward and Conway. The specimens from Spokane, are clearly legumes, as I have shown elsewhere (Brown, 1937, p. 177).

Some of the leaves and fruit (pl. 56, figs. 1, 2, 3) from the Wilcox group of southwestern Tennessee were collected by Dr. R. Lee Collins, University of Tennessee, who deserves much credit for his thorough search for plant remains in the deposits of that region. It is significant that at the Mandy locality the collection of leaves of this species matches almost specimen for specimen in outline and variation that from the Fort Union formation at Dickinson, N. Dak.

Range.—This species is found from the Paleocene to middle Eocene. It ranged from the southeastern United States to Canada, Alaska, Siberia, Spitsbergen, England, and Greenland. There is some evidence that geographic races or variations existed within this widespread species; but it has not seemed feasible to attempt to distinguish them.

Typical figures.—HEER, *1868*, vol. 1, pl. 5, fig. 3; *1869*, vol. 2, no. 4, pl. 44, fig. 8a.—WARD, *1887*, pl. 4, fig. 1; pl. 7, fig. 2.—NEWBERRY, *1898*, pl. 27, fig. 1.—KNOWLTON, *1899*, pl. 84, fig. 1; pl. 85, figs. 1, 2.—PENHALLOW, *1908*, text fig. 14.—BERRY, *1916*, pl. 48, fig. 9; pl. 64, figs. 4, 5.—HOLLICK, *1936*, pl. 26, fig. 5; pl. 30, fig. 4.

CERCIDIPHYLLUM ELONGATUM
Brown, n. name
Plate 55; plate 56, figs. 8, 9, 12–14

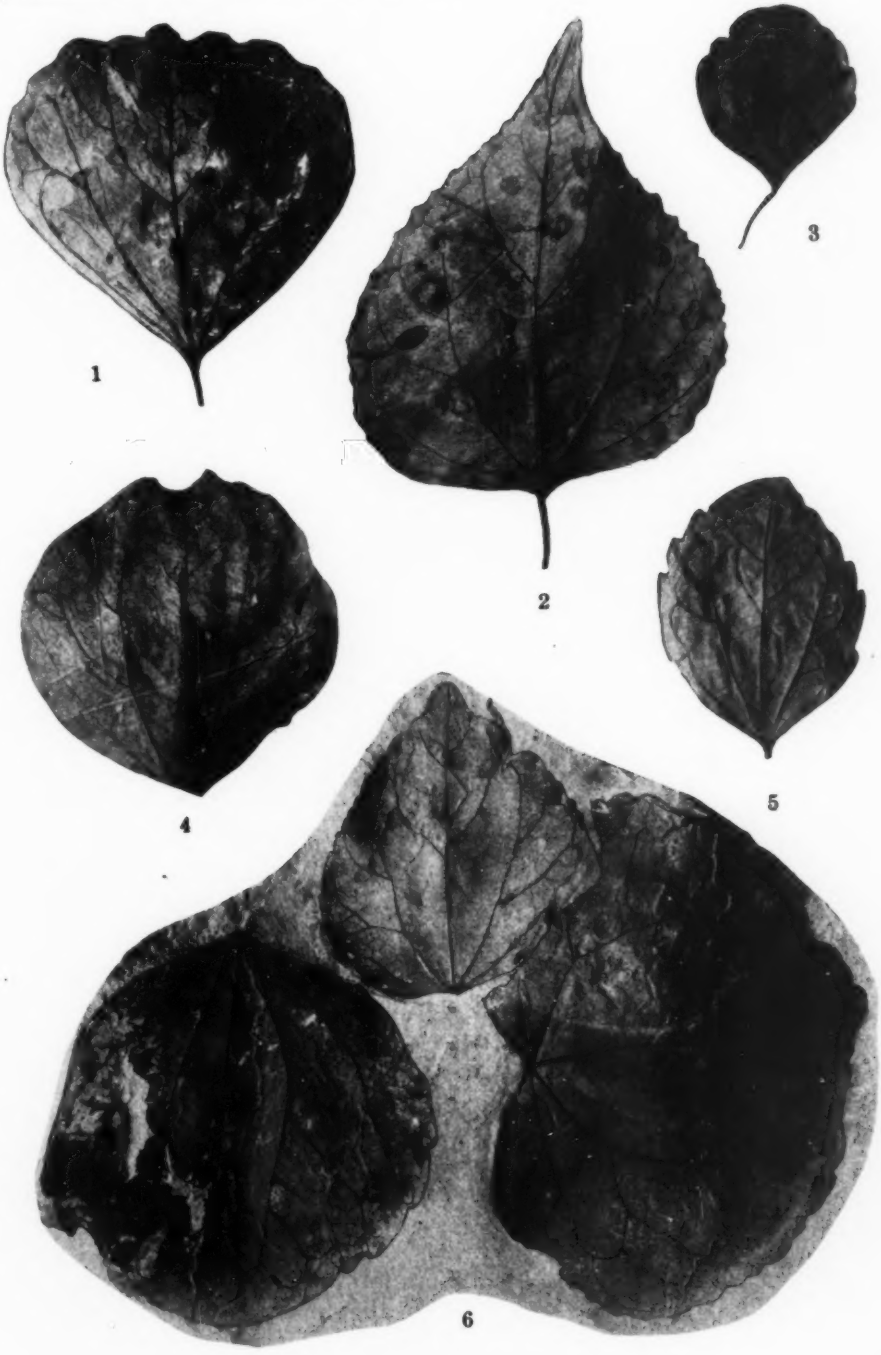
Populus zaddachi Heer. LESQUEREUX, *1878b*, p. 11, pl. 8, figs. 1–8.
Populus smilacifolia Newberry. JENNINGS, *1920*, p. 409, pl. 29, fig. 4.
Ceanothus idahoensis BROWN, *1935*, p. 581, pl. 69, fig. 8. [Omit the synonymy.]

EXPLANATION OF PLATE 53

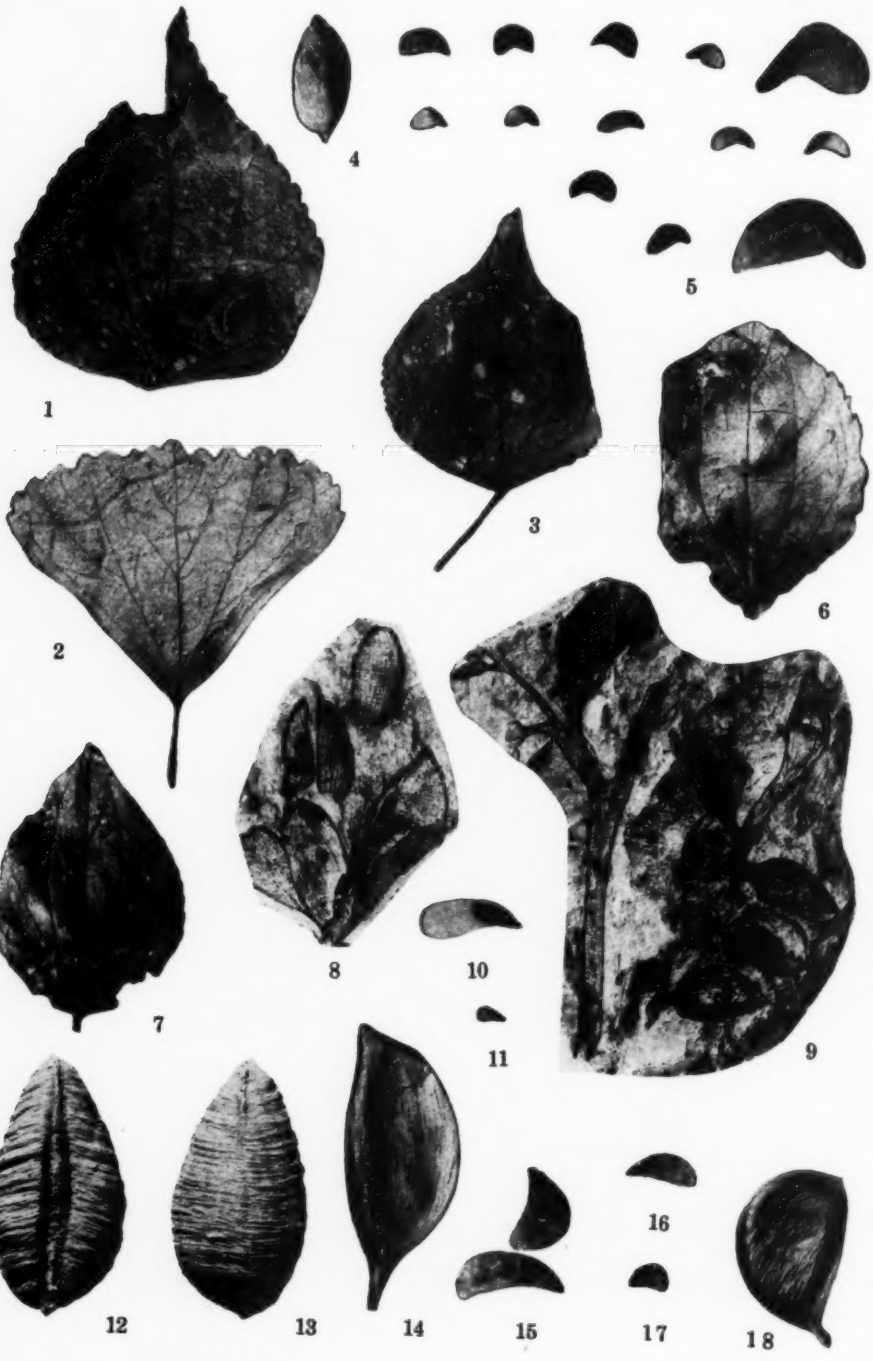
All figures natural size

Leaves of *Cercidiphyllum arcticum* (Heer) Brown from localities in the Fort Union formation (Paleocene) of North Dakota and Montana. (p. 492)

FIGS. *1, 6*—West side of Little Missouri River, 2 miles south of Medora, N. Dak.
2—At south corner secs. 34 and 35, T. 2 N., R. 44 E., south of Rosebud, Mont.
3—On Cherry Creek, 10 miles north of Terry, Mont.
4—On left bank of Yellowstone River, at Burns Ranch, 30 miles northeast of Glendive, Mont.
5—On Yellowstone River, Mont. Reproduced from Newberry, 1898, pl. 28, fig. 3.



Brown, *Cercidiphyllum articum*



Brown, *Cercidiphyllum*

Trochodendroides zaddachi (Heer) SANBORN, *1935*, p. 16, pl. 3, fig. 2.

The leaf norm of this species is elongate, broadly lanceolate, with a cordate base and rounded to rounded-crenate teeth; but, as in all species of *Cercidiphyllum*, a considerable range of variation is present. The fruits and seeds so far seen are small.

In outline and venation some specimens of this species are, at least superficially, very similar to some specimens of *Populus zaddachi* Heer, and misidentifications based upon these resemblances are not surprising. The types of *P. zaddachi* are from the Oligocene lignitic strata of the Samland near Königsberg, Germany. Heer published a description (1859, p. 307), which was repeated in 1860 by Zaddach, who added a plate of excellent illustrations (1860, pp. 27–30, pl. 4). In 1869 Heer published additional figures (1869, p. 30, pl. 5; pl. 6; pl. 12, fig. 1c.). If the illustrations as published were correctly drawn there would seem to be little doubt that the species is a true *Populus*. Zaddach's figure 9 in particular displays a strong secondary vein coming off from the midrib much below the level in normal leaves of *Cercidiphyllum*. Furthermore, most of the Zaddach and Heer illustrations can be matched with leaves from *Populus balsamifera* or its varieties. Saporta's illustrations (1892, p. 67, pl. 17, figs. 11–16; pl. 18, figs. 1–3; pl. 19, figs. 1–2) of this species, if it is the same species, definitely show acropetiolar glands. Kirchheimer (1937, p. 51), although he discussed the flora from the Braunkohlen and cited other species of *Populus*, did not consider *P. zaddachi*.

In 1935 I regarded my own material from Salmon, Idaho, and the Missoula, Mont., specimens identified as *Populus zaddachi* Heer by Jennings (1920, p. 406), as rhamnaceous in character and called them all *Ceanothus idahoensis*. Since then I have discovered in the Missoula collections a *Populus* fruit (Brown, 1937a, p. 506) and leaves like those described by Jennings having marked acropetiolar glands—facts which convince me that some, if not all, of Jenning's specimens are indeed true *Populus*. However, during the field season of 1938, I also found the fruits, seeds, and fragmentary leaves of a *Cercidiphyllum* in the same strata, so that it is now clear that both genera are present in the Tertiary beds in the vicinity of Missoula.

The question now arises: Is the name *Populus zaddachi* Heer justifiably applied to some American specimens of true *Populus*? This is not the place to answer that question, nor to review the fossil species of *Populus*, but it may be well to call attention to one misidentification, namely *P. zaddachi* Herr (LESQUEREUX, *1883*, p. 158, pl. 31, fig. 8) which is a small specimen of *P. lesquereuxi* Cockerell in the Florissant flora. Inasmuch as Lesquereux's specimens from Chalk Bluffs, Calif., were apparently the first of this kind to be erroneously called *Populus zaddachi* Heer, and because they are the types of the species, I propose to give them a new name, *Cercidiphyllum elongatum*, and to bring all pertinent citations subsequent to that of Lesquereux into synonymy.

Range.—This species developed during the middle or late Eocene and extended from northern California to Washington, Idaho, and western Montana, where it survived un-

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EXPLANATION OF PLATE 54

All figures natural size except as indicated

FIGS. *1–7*, *12*, *13*, *17*—Leaves, fruits, and seeds of *Cercidiphyllum articum* (Heer) Brown, from the Fort Union formation (Paleocene). *1–5*, From clay pit 1 mile south of Dickinson, N. Dak. Two large seeds at right of group in *5*, ×3. *6*, *7*, Along road between Bicycle and Grassy Butte, N. Dak. *12*, *13*, From bluffs 1½ miles northwest of Coal Harbor, N. Dak. ×2. *17*, From sec. 2, T. 137 N., R. 84 W., east of Almont, N. Dak. (p. 492)

8–11, *14–16*.—Fruits and seeds associated with *Cercidiphyllum ellipticum* (Newberry) Brown. *8*, *9*, From Tullock formation (Paleocene), 9 miles west of Miles City, Mont. *10*, From basal Fort Union, sec. 3, T. 35 N., R. 66 W., west of Lance Creek, Wyo. ×3. *11*, From Denver formation (Paleocene), 100 feet below lava cap of South Table Mt., Golden, Colo. *14*, *15*, From Evanston formation (Paleocene) in Union Pacific R.R. cut 1 mile east of Evanston station, Wyo. *16*, From Denver formation (Paleocene) on bank of Second Creek 10 miles east of Derby, Colo. ×3. (p. 491)

17—Fruit of a living *Connarus* sp. for comparison with fossil fruits of *Cercidiphyllum*.

til probably upper Oligocene or lower Miocene time.

Typical figures.—LESQUEREUX, *1878b*, pl. 8, figures 1, 2.—BROWN, *1935*, pl. 69, fig. 8.—SANBORN, *1935*, pl. 3, fig. 2.

CERCIDIPHYLLUM CRENATUM (Unger) Brown

Plate 56, figures 7, 15, 16.

Cercidiphyllum crenatum (Unger) BROWN, *1935*, p. 575, pl. 68, figs. 1, 6, 8–10.—*1937a*, p. 509, fig. 9.—DORF, *1936*, p. 117, pl. 2, fig. 9. To the synonymy by Brown add the following citations:

Dombeyopsis grandidentata ETTINGSHAUSEN, *1857*, p. 18, pl. 2, fig. 9.

Dombeyopsis helicteroides ETTINGSHAUSEN, *1857*, p. 18, pl. 2, fig. 2.

Zizyphus daphnogenoides ETTINGSHAUSEN, *1857*, p. 21, pl. 2, fig. 7.

Ceanothus macrophyllos ETTINGSHAUSEN, *1857*, p. 22, pl. 2, fig. 3.

Grewia crenata (Unger) Heer. ETTINGSHAUSEN, *1869*, p. 15, pl. 42, fig. 7.—STAUB, *1881*, p. 31, pl. 3, figs. 2, 3.—VELENOVSKY, *1881*, p. 36, pl. 9, figs. 10–14.—ENGELHARDT, *1885*, p. 51, pl. 10, figs. 33–35; pl. 11, figs. 20, 24, 25; pl. 12, figs. 1–4.—ENGELHARDT, *1891*, p. 52, pl. 11, fig. 1.—KNOWLTON, *1902*, p. 80.—KRÄUSEL, *1919*, p. 417, pl. 12, figs. 2, 3.—KRYSHTOFOVICH, *1921*, p. 10, pl. 3, fig. 7.—HOLLICK, *1936*, p. 145, pl. 84, fig. 1.

Grewia orbiculata HOLLICK, *1936*, p. 146, pl. 83, figs. 1–4; pl. 84, figs. 3–5.

Grewia ovalis HEER, *1859*, p. 44, pl. 110, fig. 12.—VELENOVSKY, *1881*, p. 37, pl. 9, fig. 15.

Grewia arcinervia HEER, *1859*, p. 44, pl. 110, fig. 13.

Ficus asarifolia Ettingshausen. ENGELHARDT, *1885*, p. 26, pl. 4, figs. 32–34; pl. 5, fig. 2.

FRUITS AND SEEDS ASSOCIATED WITH C. CRENATUM

Podogonium knorrii (Braun) HEER, *1859*, vol. 3, pl. 114, pl. 135, fig. 19.

Embothrium microspermum Heer. ENGELHARDT, *1885*, p. 35, pl. 6, fig. 6.

Embothrium leptospermon Ettingshausen. ENGELHARDT, *1885*, p. 35, pl. 6, fig. 8.

The leaf norm of this species is distinctly asymmetric, cordate, and slightly elongate in proportion to its width. The fruits and seeds are almost indistinguishable from those of *C. japonicum*. Heer's figure 19 of *Podogonium knorrii* is that of a pod so strikingly like those of *C. japonicum*, and so different from those called *P. knorrii* on the same plate, that there can scarcely be any question of its relationship with the leaves called *Grewia crenata* also reported by Heer and herein regarded as *Cercidiphyllum crenatum*. The seeds ascribed by Heer to *Grewia crenata* need to be reexamined.

A fossil leaf species somewhat suggestive of *Cercidiphyllum crenatum* is that called *Populus potomacensis* Ward (BERRY, *1911*, p. 458, pl. 81, figs. 1–1e) from the lower Cretaceous Patapsco formation at Mount Vernon and White House Bluff, Va. The venation, however, is greatly forked and looped, and the petiole is so broad and flat that this species, although perhaps not a *Populus*, is also most likely not a *Cercidiphyllum*. The resemblance to the leaves of some species of *Viola* is most striking, but the probability is that it was the leaf of a woody not an herbaceous plant. At any rate no fruit or seeds resembling those of *Cercidiphyllum* have yet been found in these early Cretaceous deposits.

Range.—The earliest American specimens appear in the Tertiary of Alaska and in the shales on Bridge Creek, 9 miles northwest of Mitchell, Ore., which are thought to be of upper Oligocene or lower Miocene age. Those described by Heer are from the Oligocene of northern Switzerland and the Tertiary of Spitsbergen. Heer's specimens from Spitsbergen and Hollick's from Alaska are associated with leaves and fruits of the *C. arcticum* type. The smoother fruits of *C. crenatum* have not yet been reported from those strata. It would seem, therefore, that *C. crenatum* originated somewhat earlier than the first specimens found in the United States would indicate, and that, in the north polar regions at least, *C. crenatum* and *C. arcticum* may have been partly contemporaneous. The species apparently became extinct in America during the late Miocene.

Typical figures.—HEER, *1859*, pl. 109, figs, 12, 12b, 12c; pl. 135, fig. 19.—BROWN, *1935*, pl. 68, figs. 1, 6, 8–10.—HOLLICK, *1936*, pl. 83, figs. 1–4.

CERCIDIPHYLLUM JAPONICUM Siebold and Zuccarini

Plate 51

Cercidiphyllum japonicum Siebold and Zuccarini. NATHORST, *1888*, p. 34, pl. 9, figs. 16, 17; pl. 10, fig. 10.—ENDO, 1935, p. 662.

Nathorst's specimens of seeds and leaves from Shiobara, Japan, and thought by him to be of Pliocene age, are now considered by Endo to be from Pleistocene deposits. It

seems most likely that this species originated from *Cercidiphyllum crenatum* near the close of the Miocene or early in the Pliocene. *Cercidiphyllum japonicum* and its variety, *sinense*, have become restricted to eastern Asia; but they have been widely introduced as handsome ornamentals in other parts of the world.

CONCLUSIONS

Five nominal species of *Cercidiphyllum* are here differentiated among the large number of fossil leaves hitherto referred to *Populus* and numerous other genera. The reference of these leaves to *Cercidiphyllum* is based not only upon the characters of the leaves but upon distinctive fruits and seeds found associated with the leaves. The leaves of the living *C. japonicum* display such great variation that it is believed most of the fossil forms can be matched; or, in short, that the living species may repeat forms that existed in its history. The selection of leaf norms based upon this variation permits at least a segregation of arbitrary fossil species that seem to be more satisfactory than the many poorly defined species now listed.

It would seem that the earliest species had an elliptic leaf outline, out of which developed the deltoid form, which in turn gave place to the elongate-ovate-cordate type, and this to the asymmetric-cordate and finally to the living species. The elliptic species is essentially a Cretaceous-Paleocene form; the deltoid, Paleocene-Eocene; the elongate-cordate, Eocene-Oligocene; the asymetric-cordate, Oligocene-Miocene; and the living species probably dates from the late Miocene or Pliocene. I have no convincing speculations to offer as to the place of origin of *Cercidiphyllum*.

As to whether some of these fossil species were vines or shrubs, not trees, there is no direct evidence. There are reasons for suspecting that *C. ellipticum* and *C. arcticum* grew at relatively low altitudes in warm temperate environments, for their remains are found most abundantly in deposits that accumulated at or near sea level, and that at numerous localities included the remains of palms. The living species, *C. japonicum*, grows luxuriantly at an elevation of about 4,500 feet in the mountains of central Japan, and the variety *sinense* in the mountains of western China.

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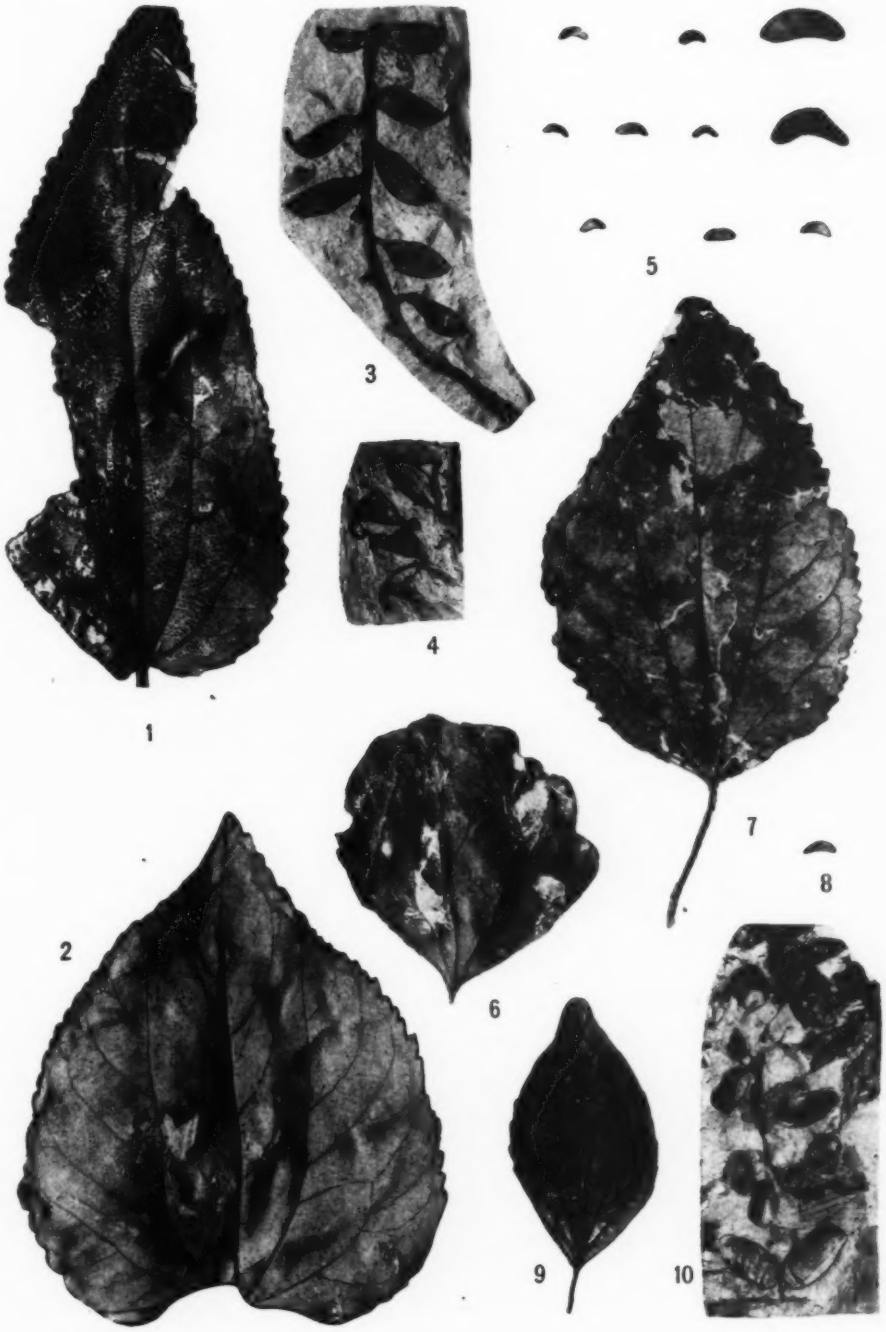
EXPLANATION OF PLATE 55

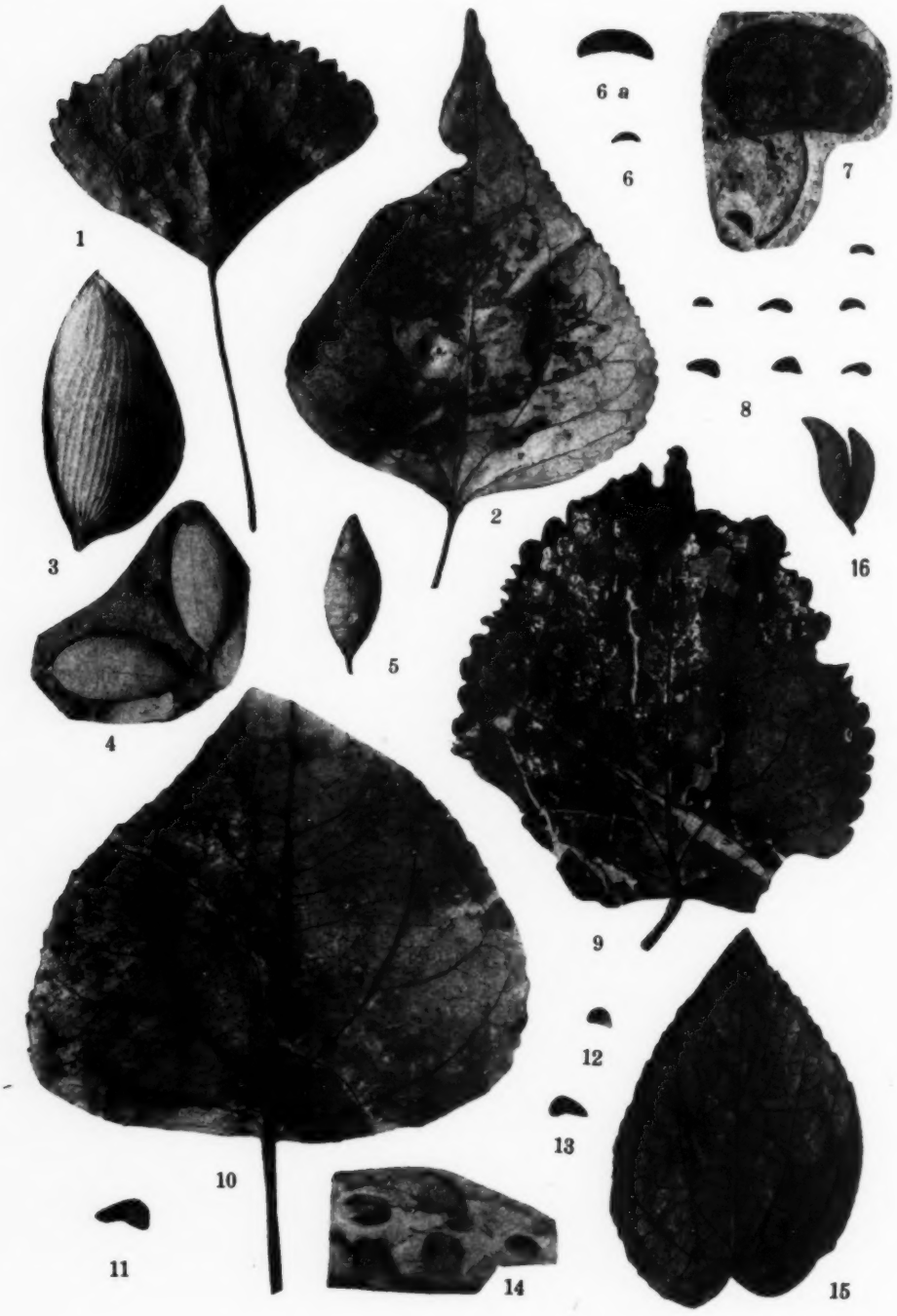
Leaves, fruits, and seeds of *Cercidiphyllum elongatum* Brown. (p. 494)

FIGS. *1–5*—From clays (probably upper Eocene) in auriferous gravels at You Bet, Nevada County, Calif. Large seeds at right of *5*, ×3.

6–10—From strata (probably upper Eocene) at Steel's Crossing, southeast of Seattle, Wash. ×1.



Brown, *Cercidiphyllum elongatum*



Brown, *Cercidiphyllum*

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EXPLANATION OF PLATE 56

All figures natural size except as indicated

FIGS. *1-6a*, *10*, *11*—Leaves, fruits and seeds of *Cercidiphyllum arcticum* (Heer) Brown. *1–6a* from Wilcox group (lower Eocene). *1*, *2*, From Gulf Mobile & Northern R.R. cut, ¼ mile south of Mandy, Madison County, Tenn. *3*, On Young farm, northwest of Shandy, Hardeman County, Tenn. ×3. *4*, *5*, From Gulf Mobile Northern R.R. cut at Pine Top, Hardeman County, Tenn. *6*, *6a*, From north bank of Loosahatchie River at Somerville, Fayette County, Tenn. *6a*, ×3. *10*, *11*, From Green River formation (middle Eocene), 30 miles northwest of DeBeque, Colo. *11*, ×3. (p. 492)

7, *15*, *16*—Leaves, seed, and fruit of *Cercidiphyllum crenatum* (Unger) Brown. *7*, *15*, From probable lower Miocene at Republic, Wash. *16*, From upper Oligocene or lower Miocene on Bridge Creek, 9 miles northwest of Mitchell, Ore. (p. 496)

8, *9*, *12–14*—Leaves, fruits, and seeds of *Cercidiphyllum elongatum* Brown *8*, *9*, From probable upper Oligocene at G. W. Oliver coal prospect, Salmon, Idaho. *12–14*, From probable Oligocene, 10 miles northwest of Missoula, Mont. (p. 494)

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MIDDLE DEVONIAN POLYCHAETA FROM THE LAKE ERIE DISTRICT

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ABSTRACT—In addition to the annelid jaws which Dr. Hinde obtained from the Hamilton beds at Arkona, Ontario, various others have been found in these shales at the same place and in beds of similar age south of Lake Erie. Thirty-six new and several other partially known species are figured and described, thus more than tripling the known polychaetous fauna from that region.

ANNELID jaws have been encountered in sediments ranging in age from the Cambrian to the present. In order to have a convenient term covering all the objects commonly referred to as worm teeth, the name "scolecodont" (1) has been introduced. The scolecodonts here under discussion are all known to belong to the Polychaeta and hence this latter term is used.

Fossil Polychaeta are common in the Devonian sediments over wide areas, and at some places in America they are abundant. The Thedford-Arkona region in Ontario has proven exceedingly rich in such remains and especially in the part of the Hamilton that has been designated the Olentangy shale. This is a soft blue shale with lenses and concretions of limestone and occasional thin layers of brown to black shale. Trails and burrows may be observed commonly in the shale or in the limestone lenses. The bottom layer of the Canadian Encrinal (probably Prout) limestone fills or fits into large furrows that were surface trails of this sort, and associated with these are the teeth of Polychaeta, conodonts, and fish, together with phosphatic coprolitic bodies of unknown origin. All these have been washed from numerous shale samples or have been separated from the limestones by leaching and solution. Teeth or jaws of Polychaeta are chitinous, hence solution in HCl or HNO_3 is exceedingly slow or nil, and the specimens may be prepared readily for study even from limestones. As the strata in which Polychaeta occur abundantly show evidences of shallow water deposition, and as the jaws are associated with other fossil forms of near-shore origin, it may be safe to conclude that the presence of fossil Polychaeta, like the presence of their living representatives, may be taken as an indication of nearness to a shore line. In the case of fossil forms this means an ancient shore line, and perhaps this in turn may be important in the study of a convergent series of sediments. At any rate remains of Polychaeta form an important and valuable contribution to the record of ancient sediments.

The similarity of certain Devonian Polychaeta to the forms occurring in the Ordovician has been pointed out (2), and the similarity of many Paleozoic forms to the living Polychaeta has been noted by nearly every writer on the subject from the earliest discoveries to the present. Evidently from the Cambrian down the Polychaeta have constituted a very homogenous and conservative class of organisms well adapted to its environment and abundantly able to cope with the problems of a migrating shore line or the appearance of new forms of competing life.

Most of the Devonian fossil specimens appear to be maxillae I and II, although an occasional mandible has been found. These different units probably occupied the same positions in relation to the mouth as they do in the modern forms, but for descriptive purposes they are commonly placed with the long axes in the horizontal position.

The difficulties encountered in the study of scolecodonts were appreciated by Dr. Hinde. Thus he quotes M. Claparède, presumably a contemporary authority on recent Annelids, "On one hand very different jaws are met with in the same genus; on the other identical jaws are frequently in different genera" (3). And, since there is every evidence that the fossil Polychaeta possess

the same dental variation as one finds in the modern forms, uncertainty must be recognized as an important factor in any classification offered.

The following descriptions give briefly the characteristics of the new species illustrated on the accompanying plates, which were drawn by Louise F. Bush:

DESCRIPTION OF SPECIES

Genus ARABELLITES Hinde, 1879

ARABELLITES ADAMSI
Stauffer, n. sp.
Plate 57, figure 29

Jaw elongate, broad at base, becoming depressed and tapering anteriorly; extending forward into a large curved hook somewhat as restored. Denticulated edge preserving half a dozen small inwardly curving teeth. which increase in size towards the anterior. Denticulated edge continued as a smooth ridge to truncated base and forming the margin of a pit or depression that is bounded on inner side by a short, stout ridge. Basal opening and hollow large.

Holotype.—B 5382; Geological Museum, University of Minnesota.

Horizon and locality.—Olentangy shale 11 feet below the base of the Ohio shale at Sulphur Lick School, Adams County, Ohio.

ARABELLITES ANATINUS
Stauffer, n. sp.
Plate 58, figures 40–42, 50

Plate elongate, wide, sides nearly parallel and extending forward into a stout recurved hook. Posterior deeply notched or arcuate, with a broad furrow or depression extending along the plate near the dental ridge. Outer portion of plate thickened and continuous into curve of hook. Eight to 10, possibly more, small subequal conical denticles incline to posterior and at right angles to plane of base along edge of slight ridge on inner side of plate. Attachment side flattened, and with a broad open depression that passes into the hollow of the hook.

This type of jaw falls under Hinde's genus *Arabellites*, and the species here described is very similar to one of his from the Silurian of Gotland. If, however, they are maxillae I, as they appear to be, they are so different from the more normal form of the genus that they should be separated from it.

Syntypes.—B 5419, B 5420, B 5421, B 5429; Geological Museum, University of Minnesota.

Horizon and locality.—Widder beds, James Bell quarry, Thedford, Ontario; and top of Olentangy shale, Marsh's Mill (Hungry Hollow), Ontario.

ARABELLITES ARCUATUS Hinde
Plate 58, figure 17

Arabellites arcuatus HINDE, *1879*, Geol. Soc. London, Quart. Jour., vol. 35, p. 385, pl. 20, fig. 20.

Plate elongate, subtriangular, laterally compressed, with the basal spine or spur curving off to side just anterior to middle of jaw. Main denticle about twice average size and preceded by two unusually small ones that may be considered on edge of the main or anterior denticle. This latter is succeeded by three small denticles and then a series of about seven or eight additional sharp, laterally compressed, backwardly directed denticles. Attachment side with pocketlike hollow extending forward into the anterior end.

Figured specimen.—B 5398; Geological Museum, University of Minnesota.

Horizon and locality.—Ipperwash limestone, Ipperwash Beach, Ontario.

ARABELLITES AUSABLENSIS
Stauffer, n. sp.
Plate 58, figure 2

Jaw elongate, with short, stout, sharp anterior denticle, succeeded along dental edge by a decreasing series of small and larger, backward-curving, laterally compressed denticles. Upper surface slightly concave towards the anterior. Basal spine a downward continuation of the inner side of base of anterior denticle; thin and curving slightly upward. Attachment side of base hollow and open throughout length.

Holotype.—B 5385; Geological Museum, University of Minnesota.

Horizon and locality.—Top of Olentangy shale, Marsh's Mill (Hungry Hollow), Ontario.

ARABELLITES COMIS Eller
Plate 58, figures 21, 22, 28

Arabellites comis ELLER, *1938*, Carnegie Mus., Annals, vol. 27, p. 277, pl. 28, fig. 9.

Jaw rather small, thin and subtriangular in outline. Posterior obliquely truncate but

may show spurlike projections from the hollow attachment side. Anterior part of jaw slender and bending upward into a terminal denticle, which curves slightly inward. Dental ridge rather sharp and bearing 6 to 8 or more slender denticles, which decrease gradually in size to posterior and may vary in inclination from anterior through erect to posterior. Attachment side with pocketlike hollow extending forward from large posterior opening.

Figured specimens.—B 5402, B 5403, B 5409; Geological Museum, University of Minnesota.

Horizon and locality.—Top of Olentangy shale at Marsh's Mill (Hungry Hollow); and from the Widder beds, James Bell quarry, Thedford, Ontario.

ARABELLITES CULTRIFORMIS
Stauffer, n. sp.
Plate 58, figures 9, 10

Base broadly sickle-shaped, compressed or flattened. Two anterior denticles but slightly enlarged, bent to posterior and succeeded by 8 or 10 curved denticles of decreasing size. Basal spur or spine slender, tapering, approaching parallelism with denticulated ridge and about half its length. Attachment side of base with furrowlike hollow. Spur or spine probably solid, but the anterior part of the furrow shows a branch extending anteriorly.

Syntypes.—B 5391, B 5392; Geological Museum, University of Minnesota.

Horizon and locality.—Top of Olentangy shale, Marsh's Mill (Hungry Hollow), Ontario; also Widder beds, James Bell quarry, Thedford, Ontario.

ARABELLITES DAUPHINENSIS
Stauffer, n. sp.
Plate 58, figure 4

Jaw elongate, flattened, with short flange along posterior under side. Anterior end with strong short hooklike denticle quite out of line with the row of about a dozen small teeth along the dental ridge. Basal spine or spur long, nearly at right angles to dental ridge, and about midway from the basal extremities. Attachment side showing hollow in posterior half.

Holotype.—B 5387; Geological Museum, University of Minnesota.

Horizon and locality.—Ipperwash limestone, Ipperwash Beach, Ontario.

ARABELLITES FALCIFORMIS
Stauffer, n. sp.
Plate 58, figures 13, 15, 16

Plate elongate, rather shallow, moderate width. Two prominent anterior denticles succeeded by 2 or 3, possibly more, small denticles, then a series of 8 to 10 or more somewhat larger, backwardly inclined, laterally compressed denticles along the dental margin or ridge. Basal spine or spur long, thin, and its outer edge continuing the edge of outermost anterior denticle. Attachment side of jaw with an elongate furrow that becomes a pocketlike hollow at anterior.

Syntypes.—B 5394, B 5396, B 5397; Geological Museum, University of Minnesota.

Horizon and locality.—Ipperwash limestone, Ipperwash Beach, Ontario; and Widder beds, James Bell quarry, Thedford, Ontario.

ARABELLITES JUBATUS
Stauffer, n. sp.
Plate 58, figure 3

Jaw with anterior of plate terminating in a prominent, strong, backwardly curving denticle, with carinated edges 90° or more out of line with the denticular edge, which in this species is nearly at right angles to the plane of the base and carries about 6 to 8 strong, backwardly curving denticles. Anterior of base flattened-concave, with basal spine a continuation of carinate edge of anterior denticle and nearly parallel to dental ridge. Attachment side of base hollow extending forward into pocketlike termination.

Holotype.—B 5386; Geological Museum, University of Minnesota.

Horizon and locality.—Widder beds, James Bell quarry, Thedford, Ontario.

ARABELLITES LAUTUS
Stauffer, n. sp.
Plate 58, figures 11, 12

Base elongate, narrow, shallow and tapering to posterior. Anterior denticle prominent and hooklike, somewhat offset from dental series, which starts with two small ones, the third much enlarged and succeeded by 6 or more backward-curving denticles of

decreasing size. All denticles are sharp and laterally compressed. Basal spur short and a continuation of outer margin of base, which is concave between this and denticulated ridge. This concavity extends up side of anterior hooklike denticle. Attachment side of ridge hollow throughout.

Holotype.—B 5393; Geological Museum, University of Minnesota.

Horizon and locality.—Ipperwash limestone, Ipperwash Beach, Ontario.

ARABELLITES MAGNIFICUS
Stauffer, n. sp.
Plate 57, figure 7;
plate 58, figures 1, 14

Jaw curved or arched, with a smooth downward projecting shank or limb near the inner end. Denticulated edge bearing about 9 backward-curving pointed teeth of uneven size. Attachment side with a furrow along base and part of shank, passing into a shallow anterior hollow.

Syntypes.—B 5363, B 5384, B 5395; Geological Museum, University of Minnesota.

Horizon and locality.—Silica shale two feet above the limestone at Silica, Ohio; also Widder beds, James Bell quarry, Thedford, Ontario; and top of Olentangy shale at Marsh's Mill (Hungry Hollow), Ontario.

ARABELLITES MAGNISULCATUS
Stauffer, n. sp.
Plate 58, figure 8

Base deeply notched from posterior, giving it a distinct V shape between the denticulated ridge and the unusually long prominent spur. Anterior denticle small, and after a space succeeded by 5 or 6 denticles of nearly the same size. Denticulated ridge thick and hollow on attachment side with wide opening.

Holotype.—B 5390; Geological Museum, University of Minnesota.

Horizon and locality.—Widder beds, James Bell quarry, Thedford, Ontario.

ARABELLITES MINUTUS
Stauffer, n. sp.
Plate 57, figure 21

Jaw small, with slightly curving row of about 8 subequal teeth along outer margin. The cusplike tooth at anterior end fairly large, with base projecting downward from jaw, and its inner edge forming the edge of the smooth inner limb. Base with wide-open hollow. Much chitinous tissue still clings to this specimen.

Holotype.—B 5376; Geological Museum, University of Minnesota.

Horizon and locality.—Olentangy shale 26 feet below the Encrinal limestone at Marsh's Mill (Hungry Hollow), Ontario.

ARABELLITES MODESTUS
Stauffer, n. sp.
Plate 58, figures 43, 45

Jaw consisting of rhombic plate, with upper side convex and upper anterior corner curving forward into a slender hook. Posterior expanded into a slight collar or frill. Six to 8 or more small erect teeth or denticles along dental edge. Attachment side concave and hook hollow.

Syntypes.—B 5422, B 5424; Geological Museum, University of Minnesota.

Horizon and locality.—Widder beds, James Bell quarry, Thedford, Ontario.

ARABELLITES OBLATUS
Stauffer, n. sp.
Plate 58, figures 30, 37

Plate slender, elongate, tapering to anterior. Posterior truncated and a corner projecting downward into a basal spine. Inner margin a rounded ridge, which continues forward into the well-developed hook. Dental ridge bearing a series of low denticles or coarse crenulations, which extend up the side of the hook. This latter is at right angles to the dental ridge. Attachment side with a broad open hollow, which becomes pocketlike in the middle of the base.

Holotype.—B 5411; figured specimen, B 5417; Geological Museum, University of Minnesota.

Horizon and locality.—Widder beds, James Bell quarry, Thedford, Ontario.

ARABELLITES PECTINELLUS
Stauffer, n. sp.
Plate 58, figure 7

Plate short, wide, with shallow concavity on upper side. Anterior tooth elongate, sharp, curved hooklike, and succeeded immediately by a curving row or decreasing series of 7 or 8 denticles along the denticulated ridge or margin, which tapers beyond

to a point. Basal spine or spur slender and at right angles to denticulated ridge. Posterior of plate with wide arcuate notch. Attachment side with hollow, which widens toward anterior.

Holotype.—B 5389; Geological Museum, University of Minnesota.

Horizon and locality.—Ipperwash limestone, Ipperwash Beach, Ontario.

Arabellites politus Hinde

Arabellites politus Hinde, *1879*, Geol. Soc. London, Quart. Jour., vol. 35, p. 384, pl. 20, fig. 19.

Horizon and locality.—Hamilton beds, Ausable River, Arkona, Ontario.

Arabellites priscus
Stauffer, n. sp.
Plate 58, figure 18

Plate elongate, rather thick; anterior denticle strong, curved out of line with dental ridge, and tapering to an abrupt point. This is succeeded along the dental ridge by about 18 or 20 small backwardly directed teeth or denticles. Basal spine prominent, thin, and curving out away from plate near its middle. Attachment side with a crescent-shaped opening into the hollow of the base.

Holotype.—B 5399; Geological Museum, University of Minnesota.

Horizon and locality.—Widder beds, Paisley farm, Port Frank road, Thedford, Ontario.

Arabellites productus
Stauffer, n. sp.
Plate 58, figure 29

Plate elongate, slender, with flange on lower side becoming a wide projecting extension at the posterior. Dental ridge with a sinuous row of 8 to 10 small sharp denticles. The anterior end produced into a long, slender, gradually curving hook. Attachment side with open furrow at the posterior, which passes into the hollow base of the hook.

Holotype.—B 5410; Geological Museum, University of Minnesota.

Horizon and locality.—Top of Olentangy shale, Marsh's Mill (Hungry Hollow), Ontario.

Arabellites robustus
Stauffer, n. sp.
Plate 58, figure 49

Plate relatively large, thick, with smooth surfaces and rounded margins. Posterior diagonally truncate; anterior extended into a prominent stout hook. A furrow, shallowing forward, extends along the side of denticulated ridge. The ridge bears about half a dozen indefinite denticles or crenulations, and near the anterior a short, prominent flange or shelf extends downward. Attachment side has a horseshoe-shaped depression with the upper end extending as a hollow into the hook.

Holotype.—B 5428; Geological Museum, University of Minnesota.

Horizon and locality.—Widder beds, James Bell quarry, Thedford, Ontario.

Arabellites spinosus
Stauffer, n. sp.
Plate 58, figures 5, 6

Plate short, thick, arcuate, with 3 small stout vertical teeth at anterior end succeeded by 4 or 5 short, stout, backward-curving denticles along dental ridge or margin. Basal spur slender, sharp, and relatively long. Attachment side with a narrow elongate opening along the central part of base.

Holotype.—B 5388; Geological Museum, University of Minnesota.

Horizon and locality.—Top of Olentangy shale, Marsh's Mill (Hungry Hollow), Ontario.

Arabellites sp. a
Plate 57, figures 2, 3;
plate 58, figure 24

Fragmentary posterior portions of small jaws belonging to this genus. They are doubtless the first maxillae and show a compressed straight plate, with upper edge showing 8 to 10 or more small backward-curving teeth that increase in size towards the anterior.

Figured specimens.—B 5358, B 5359, B 5405; Geological Museum, University of Minnesota.

Horizon and locality.—Olentangy shale 19 feet below the Encrinal limestone, and top of Olentangy shale at Marsh's Mill (Hungry Hollow), Ontario.

ARABELLITES sp. b
Plate 58, figure 46

This is an interesting fragment of a fairly large specimen. It may belong to one of the species described above. The base of the plate is flattened, with a posterior notch at the end of the denticulated ridge, which latter bears 8 or more similar denticles and curves towards the position of hook. Attachment side with large diagonal opening at the posterior, which passes forward into the hollow base of the jaw.

Figured specimen.—B 5425; Geological Museum, University of Minnesota.

Horizon and locality.—Top of Olentangy shale at Marsh's Mill (Hungry Hollow), Ontario.

Genus DIOPATRAITES Eller, 1938
DIOPATRAITES CONFORMIS Eller
Plate 58, figure 48

Diopatraites conformis ELLER, *1938*, Carnegie Mus., Annals, vol. 27, p. 282, 283, pl. 29, figs. 12–15.

Small nearly complete mandible, with the subquadrate to subtriangular face of frontal plate slightly curved and relatively smooth except for faint to indefinite striation. Upper edge of plate with 2 or 3 sharp denticles, the large apical one of which curves inward. The margin of this plate marked by slightly projecting flange on upper side but not distinguishable on under side. The rootlike shaft convex on upper, or oral, side but concave or with longitudinal hollow on under side.

Figured specimen.—B 5427; Geological Museum, University of Minnesota.

Horizon and locality.—Ipperwash limestone, Ipperwash Beach, Ontario.

Genus EUNICITES Ehler, 1868
EUNICITES? ALVEOLATUS Hinde

Eunicites? alveolatus HINDE, *1879*, Geol. Soc. London, Quart. Jour., vol. 35, p. 384, pl. 20, figs. 14, 15.

Horizon and locality.—Hamilton beds, Ausable River, Arkona, Ontario.

EUNICITES ANGULATUS Eller
Plate 57, figure 11

Eunicites angulatus ELLER, *1938*, Carnegie Mus., Annals, vol. 27, p. 278, pl. 28, fig. 10.

Jaw large, elongate, tapering gradually to anterior, where it terminates in a well-developed hook. Inner surface with sharp ridge or carina running full length and continuing into hook. Upper surface appears to be smooth or slightly striate and concave. Posterior processes probably for attachment. Jaw probably solid.

Figured specimen.—B 5367; Geological Museum, University of Minnesota.

Horizon and locality.—Olentangy shale 19 feet below the Encrinal limestone in Rock Glen, Arkona, Ontario.

EUNICITES? DELICATULUS
Stauffer, n. sp.
Plate 58, figures 19, 23

Jaw or plate slender, elongate, tapering to posterior. Dental ridge shallow, slightly curving, and bearing a series of 10 or 12 denticles, which start at the anterior with 2 or 3 large ones and continue in decreasing size to posterior, towards which all curve or incline. Attachment side showing elongate opening into the hollow, which extends even into the denticles.

Holotype.—B 5400; paratype, B 5404; Geological Museum, University of Minnesota.

Horizon and locality.—Widder beds, James Bell quarry, Thedford, Ontario; also Ipperwash limestone, Ipperwash Beach, Ontario.

EUNICITES GRANDIS
Stauffer, n. sp.
Plate 57, figure 8

Jaw relatively large, compressed, deep, with downward extension at lower middle, from which the margin curves upward to the shallow posterior. Inner surface smooth, nearly flat; outer with lower margin thickened, and a ridge along side of teeth. This ridge becomes more pronounced to the posterior, where it bends downward and makes a loop to join the margin, thus forming a groove or furrow along the posterior part and at the down-turned end. Anterior solid throughout. Upper margin of jaw almost straight and bearing about 15 sharp, incurving, backwardly directed teeth, the anterior of which is larger, and the two just posterior to it are smaller than the rest of the series. All teeth or denticles laterally compressed.

Holotype.—B 5364; Geological Museum, University of Minnesota.

Horizon and locality.—Olentangy shale immediately below the Encrinal limestone at Marsh's Mill (Hungry Hollow), Ontario.

EUNICITES NANUS Hinde

Eunicites nanus HINDE, *1879*, Geol. Soc. London, Quart. Jour., vol. 35, p. 384, pl. 20, fig. 18.

Horizon and locality.—Hamilton shale, Ausable River, Arkona, Ontario.

EUNICITES PALMATUS Hinde

Eunicites palmatus HINDE, *1879*, Geol. Soc. London, Quart. Jour., vol. 35, p. 384, pl. 20, fig. 17.

Horizon and locality.—Hamilton beds, Ausable River, Arkona, Ontario.

EUNICITES PERPLANUS
Stauffer, n. sp.
Plate 57, figure 6

Jaw small, depressed, slightly curved, especially at anterior end. Denticulated ridge set with a series of about 10 teeth directed slightly backward, the third from the anterior being the largest. Attachment side with elongate opening into the hollow of the anterior end.

Holotype.—B 5362; Geological Museum, University of Minnesota.

Horizon and locality.—Olentangy shale 19 feet below the Encrinal limestone at Marsh's Mill (Hungry Hollow), Ontario.

EUNICITES PLACIDUS
Stauffer, n. sp.
Plate 58, figure 31

Plate small, arcuate, the denticulated ridge marginal, curved, decreasing in elevation to posterior, and carrying a row of 8 to 10 subequal rounded denticles. The anterior inner part of base is extended into a short stout spine. Nearly the whole base is hollow or excavated.

Holotype.—B 5412; Geological Museum, University of Minnesota.

Horizon and locality.—Ipperwash limestone, Ipperwash Beach, Ontario.

EUNICITES SERRATUS
Stauffer, n. sp.
Plate 57, figures 17, 24

Jaw small, curved from base to hook, relatively deep, thick, and rounded at lower or outer margin. Upper or inner margin bearing a series of about 6 short stout erect teeth in a line 90° out of the plane of the hook. Posterior with cavity or opening into hollow part of jaw. Inner surface flattened and slightly concave. Jaw and denticles hollow.

Holotype.—B 5378; figured specimen, B 5373; Geological Museum, University of Minnesota.

Horizon and locality.—Widder beds, 26 feet above the Encrinal limestone along Rock Glen, Arkona, Ontario; also Widder beds, James Bell quarry, near Thedford, Ontario.

EUNICITES? SUBLAMELLOSUS
Stauffer, n. sp.
Plate 58, figure 25

Plate rather wide and slightly concave. Anterior denticle but slightly distinguished from the individuals of the rest of the dental series, which are all about the same size and curved gently to the posterior. Dental ridge thin, curved, and set with about a dozen laterally compressed denticles. Hollow on the attachment side, with opening a slit along the side of the jaw.

Holotype.—B 5406; Geological Museum, University of Minnesota.

Horizon and locality.—Widder beds, James Bell quarry, Thedford, Ontario.

EUNICITES TUMIDUS Hinde

Eunicites tumidus HINDE, *1879*, Geol. Soc. London, Quart. Jour., vol. 35, p. 384, pl. 20, fig. 16.

Horizon and locality.—Hamilton beds, Ausable River, Ontario.

Genus GLYCERITES Hinde, 1879

GLYCERITES DEVONICUS
Stauffer, n. sp.
Plate 57, figure 14

Jaw elongate, thick, straight. Posterior hollowed on diagonal truncation, the latter causing a blunt posterior point. Upper margin probably crenulate but not very definitely dentate, and anterior ending in hook. A small posterior slit into hollow of jaw.

Holotype.—B 5370; Geological Museum, University of Minnesota.

Horizon and locality.—Olentangy shale 19 feet below the Encrinal limestone at Marsh's Mill (Hungry Hollow), Ontario.

Genus LUMBRICONEREITES Ehlers, 1868

LUMBRICONEREITES EXPANSUS
Stauffer, n. sp.
Plate 57, figure 4

Jaw elongate, rounded in front and with smooth margin extending into a lateral shank, the posterior margin of which terminates at about midlength of jaw. Posterior half much reduced and tapering to rounded terminus, which shows a slight downward bend. Oral surface concave, and dental ridge curving forward and bearing about a dozen erect to backwardly directed teeth. Attachment side with deep furrow, which extends forward into a pocketlike hollow under the anterior teeth.

Holotype.—B 5360; Geological Museum, University of Minnesota.

Horizon and locality.—Silica shale two feet above the limestone at the clay pit, Silica, Ohio.

LUMBRICONEREITES SPECTABILIS
Stauffer, n. sp.
Plate 58, figure 20

Jaw or plate elongate, narrow, with very narrow denticulated ridge, which curves to nearly right angles at anterior and bears a series of ten or a dozen subequal, laterally compressed denticles, which disappear posteriorly before the end of the ridge. A furrow extends along the inner side of the denticular ridge, and near the middle of the base there is a well-developed flattened spur bent up parallel to the denticles. Attachment side with furrow, which is somewhat expanded at base of shank.

Holotype.—B 5401; Geological Museum, University of Minnesota.

Horizon and locality.—Top of Olentangy shale, Marsh's Mill (Hungry Hollow), Ontario.

LUMBRICONEREITES sp.
Plate 57, figures 1, 5

Fragmentary jaws consisting of a nearly straight elongate plate, with serrated or toothed edge. The teeth are nearly of same size and curve gently backward; about 10 are preserved, several of them in fragmentary condition.

Figured specimens.—B 5357, B 5361; Geological Museum, University of Minnesota.

Horizon and locality.—Silica shale two feet above the limestone at Silica, Ohio; also Olentangy shale 19 feet below the Encrinal limestone at Marsh's Mill (Hungry Hollow), Ontario.

Genus NEREIDAVUS Grinnell, 1877

NEREIDAVUS INORNATUS
Stauffer, n. sp.
Plate 58, figures 27, 33

Plate elongate, tapering slightly to anterior, where the end is turned up into a hooklike large denticle. Inner or denticular ridge bearing a series of very small denticles. A shallow furrow parallels the dental ridge. Attachment side hollow, with opening at posterior.

Syntypes.—B 5408, B 5414, Geological Museum, University of Minnesota.

Horizon and locality.—Widder beds, James Bell quarry, Thedford, Ontario; also Ipperwash limestone, Ipperwash Beach, Ontario.

NEREIDAVUS ONTARIOENSIS
Stauffer, n. sp.
Plate 57, figures 12, 13, 15;
plate 58, figures 26, 32, 34

Jaw laterally compressed, elongate, deep; posterior of base notched and showing muscular attachments. Upper edge with 20 or more fine crenulations or teeth, and anterior terminating in a strong sharp tooth, which curves slightly inward. The lower outer margin has a rim or thickened edge. A small posterior opening into hollow of jaw.

Syntypes.—B 5368, B 5369, B 5407, B 5413, B 5415; figured specimen, B 5371; Geological Museum, University of Minnesota.

Horizon and locality.—Olentangy shale 19 feet below the Encrinal limestone at Marsh's Mill (Hungry Hollow), Ontario; same horizon in Rock Glen, Arkona, Ontario; Widder beds, Paisley farm, Port Frank, Ontario; Ipperwash limestone, Ipperwash Beach, Ontario.

NEREIDAVUS PLANUS
Stauffer, n. sp.
Plate 57, figures 9, 10

Jaw compressed and relatively deep in anterior portion, truncated at posterior, where an outer flange is well developed. A pit on inner side is probably for muscular attachment. The cutting edge is smooth at

the base but becomes crenulated or even toothed in the middle and smooth again towards the anterior, where the jaw is apparently bent upward into a terminal tooth or hook. Attachment surface, more lateral than basal, consists of a rather large open grooved pit, which passes forward into a long narrow hollow. The specimen figured (fig. 9) has an elliptical opening, about midway along the jaw, into the hollow interior. This may be an individual character. It is evident, however, that most of the jaw was free.

Holotype.—B 5365; figured specimen, B 5366; Geological Museum, University of Minnesota.

Horizon and locality.—Olentangy shale 30 to 40 feet below the Encrinal limestone, Crinoid Hill, Ausable River, Ontario; also Silica shale two feet above the limestone at Silica, Ohio.

NEREIDAVUS SOLITARIUS Hinde

Nereidavus solitarius HINDE, *1879*, Geol. Soc. London, Quart. Jour., vol. 35, p. 384, pl. 20, fig. 12.

Horizon and locality.—Hamilton beds, Ausable River, Arkona, Ontario.

NEREIDAVUS sp.
Plate 57, figures 16, 27

Fragments of jaws that belong to this genus. They have a deep compressed jaw, with strong but rather slender hook and the outer margin has a thickened border. Jaw hollow.

Figured specimens.—B 5372, B 5380; Geological Museum, University of Minnesota.

Horizon and locality.—Olentangy shale 19 feet below the Encrinal limestone at Marsh's Mill (Hungry Hollow), Ontario.

Genus NOTHRITES Stauffer, 1933
NOTHRITES SULCATUS
Stauffer, n. sp.
Plate 58, figure 47

A rather large complete left mandible, with rootlike shaft irregularly rounded or cylindrical on upper side but with groovelike furrow on under side, and tapering to a blunt point. Upper portion of mandible with curved inner face of frontal plate marked by furrows that extend into the divisions between the 5 sharp conical teeth, which occupy the sharply angular upper edge. Outer apical tooth largest. Lower edge of plate with rounded overhanging margin.

Holotype.—B 5426; Geological Museum, University of Minnesota.

Horizon and locality.—Top of Olentangy shale at Marsh's Mill (Hungry Hollow), Ontario.

Genus OENONITES Hinde, 1879
OENONITES COMPARATUS Hinde

Oenonites comparatus HINDE, *1879*, Geol. Soc. London, Quart. Jour., vol. 35, pp. 384, 385, pl. 20, fig. 13.

Horizon and locality.—Hamilton beds, Ausable River, Arkona, Ontario.

Genus PROTARABELLITES Stauffer, 1933
PROTARABELLITES CANADENSIS
Stauffer, n. sp.
Plate 57, figures 18, 19;
plate 58, figures 38, 39, 44

Jaw elongate, with small marginal shank or flange and strong deeply notched upper flange. The ridge bearing about 10 denticles is marginal throughout much of its length and terminates at the forward end, where the jaw passes into the long sharp-pointed dorso-ventrally flattened hook. Attachment side with furrows beneath dental ridge and shank uniting and passing into hollow of base.

Syntypes.—B 5374, B 5418; figured specimen, B 5423; Geological Museum, University of Minnesota.

Horizon and locality.—Olentangy shale 26 feet below the Encrinal limestone and top of Olentangy shale at Marsh's Mill (Hungry Hollow), Ontario; also Ipperwash limestone, Ipperwash Beach, Ontario.

PROTARABELLITES DIMINUTUS
Stauffer, n. sp.
Plate 57, figure 28

Jaw small, slender, relatively thick; outer flange very small, inner extended along the jaw as a thickened ridge but not very prominent. Upper margin a narrow low ridge bearing a dozen or more fine crenulations, anterior terminating in a well-developed hook, which curves inward and backward. Attachment side with elliptical hole passing forward into main part of jaw.

Holotype.—B 5381; Geological Museum, University of Minnesota.

Horizon and locality.—Olentangy shale 19 feet below the Encrinal limestone at Marsh's Mill (Hungry Hollow), Ontario.

PROTARABELLITES EXCELSUS
Stauffer, n. sp.
Plate 57, figures 25, 26

Jaw much elongated and terminal tooth or hook most prominent feature. Base diagonally truncated, outer flange relatively small, with a rounded or blunt forward spine. Inner flange broad, extending along much of jaw, and bending sharply upward near the lower end of base. The ridge, bearing a dozen or more small curving denticles or teeth, becomes marginal above the short outer flange and passes gradually into a few scattered nodes at the base of the long stout hook. Attachment surface a broad open furrow, which passes forward into hollow of hook.

Holotype.—B 5379; Geological Museum, University of Minnesota.

Horizon and locality.—Olentangy shale 26 feet below the Encrinal limestone at Marsh's Mill (Hungry Hollow), Ontario.

PROTARABELLITES GIGANTEUS
Stauffer, n. sp.
Plate 57, figure 30

Jaw large, fully 3/16 inch long, the hook much drawn out, the crenulated ridge well developed on the base but flattening out towards the anterior and becoming a row of denticles (30 to 40 or more) along the oral side of the hook. Base obliquely truncated and with flange on either side. These extend as a slight rim around the opening into the hollow of the jaw. Attachment posterior, and most of jaw free. Opening into hollow of jaw is posterior and subcircular. The crenulated edge surmounts a deep groove in the hollow.

Holotype.—B 5383; Geological Museum, University of Minnesota.

Horizon and locality.—Olentangy shale 30 to 40 feet below the Encrinal limestone, on the Ausable River at Crinoid Hill, Lambton County, Ontario.

PROTARABELLITES HAMILTONENSIS
Stauffer, n. sp.
Plate 57, figures 22, 23;
plate 58, figures 35, 36

Jaw elongate, with base abruptly truncated, a wide and thin flange along outer margin; inner portion of jaw thick, with rounded margin and short groove along side of dental ridge. Denticulated edge with about 8 backwardly curving teeth. Anterior with well-developed hook, offset but parallel with denticles. Attachment side with furrow, which may be double, passing forward into hollow of hook.

Holotype.—B 5377; paratype, B 5416; Geological Museum, University of Minnesota.

Horizon and locality.—Silica shale two feet above the limestone at the clay pit, Silica, Ohio; also Widder beds, James Bell quarry, Thedford, Ontario.

Genus UNGULITES Stauffer, 1933
UNGULITES sp.
Plate 57, figure 20

A thick, massive jaw fragment showing clawlike terminal tooth and remnants of one or two on the side. The relationships of this fragment are not very clear, and it may belong to some other genus. Jaw hollow.

Figured specimen.—B 5375; Geological Museum, University of Minnesota.

Horizon and locality.—Olentangy shale 26 feet below the Encrinal limestone at Marsh's Mill (Hungry Hollow), Ontario.

DISTRIBUTION TABLE

	Ohio	Ont.
Arabellites adamsi Stauffer, n. sp.	×	
Arabellites anatinus Stauffer, n. sp.		×
Arabellites arcuatus Hinde		×
Arabellites ausablensis Stauffer, n. sp.		×
Arabellites comis Eller		×
Arabellites cultriformis Stauffer, n. sp.		×
Arabellites dauphinensis Stauffer, n. sp.		×
Arabellites falciformis Stauffer, n. sp.		×
Arabellites jubatus Stauffer, n. sp.		×
Arabellites lautus Stauffer, n. sp.		×
Arabellites magnificus Stauffer, n. sp	×	×
Arabellites magnisulcatus Stauffer, n. sp.		×
Arabellites minutus Stauffer, n. sp.		×
Arabellites modestus Stauffer, n. sp.		×
Arabellites oblatus Stauffer, n. sp.		×
Arabellites pectinellus Stauffer, n. sp.		×
Arabellites politus Hinde		×
Arabellites priscus Stauffer, n. sp.		×
Arabellites productus Stauffer, n. sp.		×
Arabellites robustus Stauffer, n. sp.		×
Arabellites spinosus Stauffer, n. sp.		×
Arabellites sp. a		×
Arabellites sp. b		×
Diopatraites conformis Eller		×
Eunicites? alveolatus Hinde		×
Eunicites angulatus Eller		×
Eunicites? delicatulus Stauffer, n. sp.		×

Eunicites grandis Stauffer, n. sp.	×	*Oenonites comparatus* Hinde	×
Eunicites nanus Hinde	×	*Protarabellites canadensis* Stauffer, n. sp.	×
Eunicites palmatus Hinde	×	*Protarabellites diminutus* Stauffer, n. sp.	×
Eunicites perplanus Stauffer, n. sp.	×	*Protarabellites excelsus* Stauffer, n. sp.	×
Eunicites placidus Stauffer, n. sp.	×	*Protarabellites giganteus* Stauffer, n. sp.	×
Eunicites serratus Stauffer, n. sp.	×	*Protarabellites hamiltonensis* Stauffer, n. sp.	×
Eunicites? sublamellosus Stauffer, n. sp.	×	*Ungulites* sp.	×
Eunicites tumidus Hinde	×		
Glycerites devonicus Stauffer, n. sp.	×		
Lumbriconereites expansus Stauffer, n. sp.	×		
Lumbriconereites spectabilis Stauffer, n. sp.	×		
Lumbriconereites sp.	×		
Nereidavus inornatus Stauffer, n. sp.	×		
Nereidavus ontarioensis Stauffer, n. sp.	×		
Nereidavus planus Stauffer, n. sp.	×		
Nereidavus solitarius Hinde	×		
Nereidavus sp.	×		
Nothrites sulcatus Stauffer, n. sp.	×		

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3. Hinde, Geo. J., *1880, Geol. Soc. London, Quart. Jour.*, vol. 36, p. 370.

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Explanation of Plate 57

Figs. *1, 5—Lumbriconereites* sp. *1*, Silica shale, Silica, Ohio; *5*, Olentangy shale, Marsh's Mill, Ontario, ×45. (p. 507)

2, 3—Arabellites sp. a. Olentangy shale, Marsh's Mill, Ontario, ×45 (p. 504)

4—Lumbriconereites expansus Stauffer, n. sp. Holotype, Silica shale, Silica, Ohio, ×30 (p. 507)

6—Eunicites perplanus Stauffer, n. sp. Holotype, Olentangy shale, Marsh's Mill, Ontario, ×45. (p. 506)

7—Arabellites magnificus Stauffer, n. sp. Syntype, Silica shale, Silica, Ohio, ×45. (p. 503)

8—Eunicites grandis Stauffer, n. sp. Holotype, Olentangy shale, Marsh's Mill, Ontario, ×20 (p. 505)

9, 10—Nereidavus planus Stauffer, n. sp. *9*, Holotype, Olentangy shale, Crinoid Hill, Ausable River, Ontario, ×20; *10*, figured specimen, Silica shale, Silica, Ohio, ×45 (p. 507)

11—Eunicites angulatus Eller. Figured specimen, Olentangy shale, Rock Glen, Arkona, Ontario, ×30. (p. 505)

12, 13, 15—Nereidavus ontarioensis n. sp. Olentangy shale, ×45. *12*, Syntype, Rock Glen, Arkona, Ontario; *13*, syntype, Marsh's Mill, Ontario; *15*, figured specimen, Marsh's Mill, Ontario. (p. 507)

14—Glycerites devonicus Stauffer, n. sp. Holotype, Olentangy shale, Marsh's Mill, Ontario, ×45. (p. 506)

16, 27—Nereidavus sp. Figured specimens, Olentangy shale, Marsh's Mill, Ontario. *16*, ×45; *27*, ×30. (p. 508)

17, 24—Eunicites serratus Stauffer, n. sp. *17*, Figured specimen, Widder beds, James Bell quarry, Thedford, Ontario; *24*, holotype, Widder beds, Rock Glen, Arkona, Ontario; ×45. (p. 506)

18, 19—Protarabellites canadensis Stauffer, n. sp. Syntype, Olentangy shale at Marsh's Mill, Ontario, ×45. *18*, Lateral view; *19*, oral view. (p. 508)

20—Ungulites sp. Figured specimen, Olentangy shale, Marsh's Mill, Ontario, ×45. (p. 509)

21—Arabellites minutus Stauffer, n. sp. Holotype, Olentangy shale, Marsh's Mill, Ontario, ×45. (p. 503)

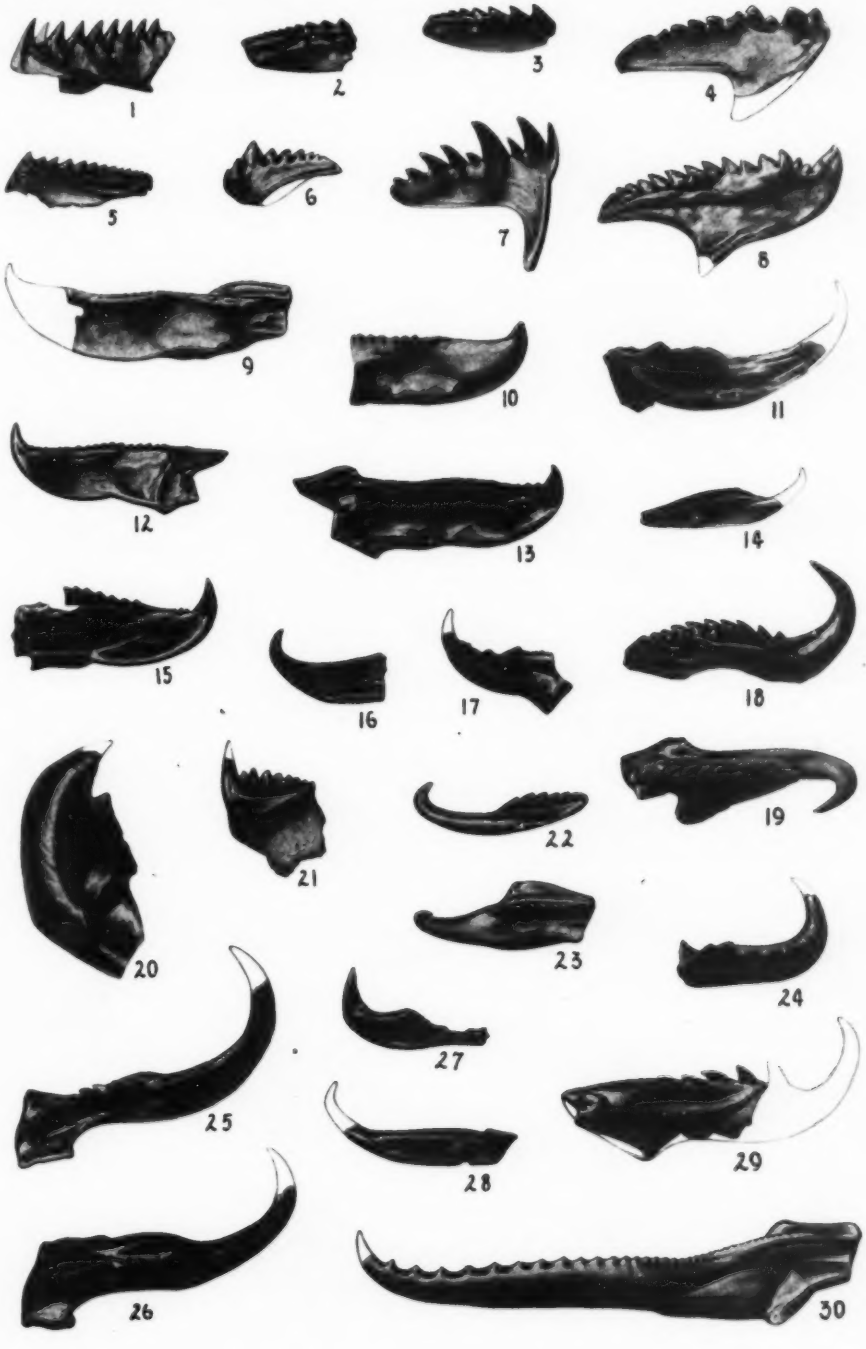
22, 23—Protarabellites hamiltonensis Stauffer, n. sp. Holotype, Silica shale, Silica, Ohio, ×30. *22*, Lateral view; *23*, oral view. (p. 509)

25, 26—Protarabellites excelsus, Stauffer, n. sp. Holotype, Olentangy shale, Marsh's Mill, Ontario, ×30. *25*, Lateral view; *26*, semioral view. (p. 509)

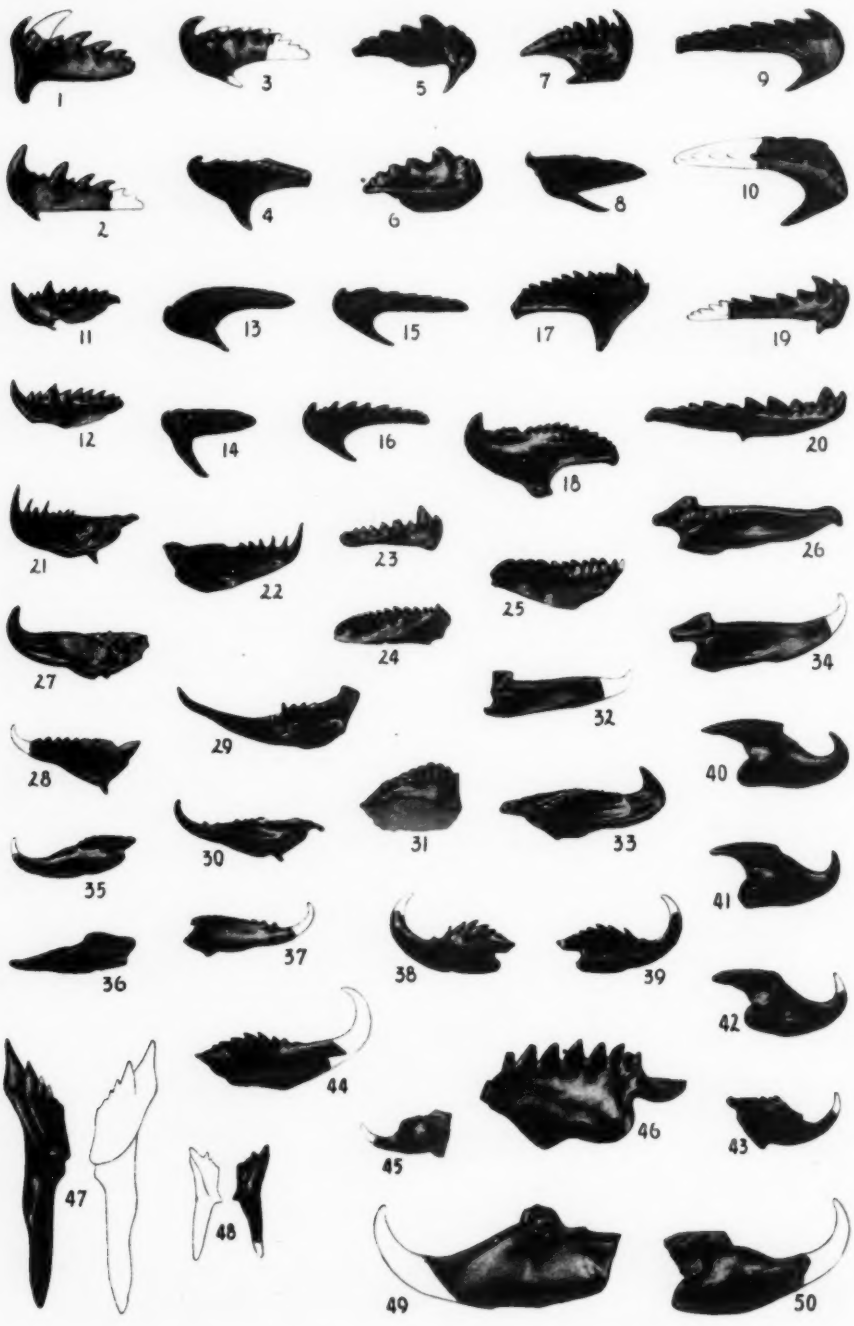
28—Protarabellites diminutus Stauffer, n. sp. Holotype, Olentangy shale, Marsh's Mill, Ontario, ×45. (p. 508)

29—Arabellites adamsi Stauffer, n. sp. Holotype, Olentangy shale, Sulphur Lick School, Ohio, ×30. (p. 501)

30—Protarabellites giganteus Stauffer, n. sp. Holotype, Olentangy shale, Ausable River, Lambton County, Ontario, ×15. (p. 509)



Stauffer, Middle Devonian Polychaeta



Stauffer, Middle Devonian Polychaeta

EXPLANATION OF PLATE 58

FIGS. *1, 14—Arabellites magnificus* Stauffer, n. sp. Syntypes, ×30. *1*, Widder beds, Thedford, Ontario; *14*, Olentangy shale, Marsh's Mill, Ontario. (p. 503)

2—Arabellites ausablensis Stauffer, n. sp. Holotype, Olentangy shale, Marsh's Mill, Ontario, ×30. (p. 501)

3—Arabellites jubatus Stauffer, n. sp. Holotype, Widder beds, Thedford, Ontario, ×30. (p. 502)

4—Arabellites dauphinensis Stauffer, n. sp. Holotype, Ipperwash limestone, Ipperwash Beach, Ontario, ×45. (p. 502)

5, 6—Arabellites spinosus Stauffer, n. sp. Holotype. Olentangy shale, Marsh's Mill, Ontario, ×45. *5*, Top side view; *6*, side view. (p. 504)

7—Arabellites pectinellus Stauffer, n. sp. Holotype, Ipperwash limestone, Ipperwash Beach, Ontario, ×45. (p. 503)

8—Arabellites magnisulcatus Stauffer, n. sp. Holotype, Widder beds, James Bell quarry, Thedford, Ontario, ×45. (p. 503)

9, 10—Arabellites cultriformis Stauffer, n. sp. Syntypes, ×45. *9*, Olentangy shale, Marsh's Mill, Ontario; *10*, Widder beds, James Bell quarry, Thedford, Ontario. (p. 502)

11, 12—Arabellites lautus Stauffer, n. sp. Holotype, Ipperwash limestone, Ipperwash Beach, Ontario, ×30. *11*, Top side view; *12*, side view. (p. 502)

13, 15, 16—Arabellites falciformis Stauffer, n. sp. Syntypes. *13*, Widder beds, James Bell quarry, Thedford, Ontario, ×30; *15*, Widder beds, James Bell quarry, Thedford, Ontario, ×45; *16*, Ipperwash limestone, Ipperwash Beach, Ontario, ×30. (p. 502)

17—Arabellites arcuatus Hinde. Figured specimen, Ipperwash limestone, Ipperwash Beach, Ontario, ×45. (p. 501)

18—Arabellites priscus Stauffer, n. sp. Holotype, Widder beds, Paisley farm, Port Frank, Ontario, ×45. (p. 504)

19, 23—Eunicites? delicatulus Stauffer, n. sp. *19*, Holotype, Widder beds, James Bell quarry, Thedford, Ontario, ×45; *23*, paratype, Ipperwash limestone, Ipperwash Beach, Ontario, ×30. (p. 505)

20—Lumbriconereites spectabilis Stauffer, n. sp. Holotype, Olentangy shale, Marsh's Mill, Ontario, ×30. (p. 507)

21, 22, 28—Arabellites comis Eller. Figured specimens. *21, 22*, Olentangy shale, Marsh's Mill, Ontario, ×30; *28*, Widder beds, James Bell quarry, Thedford, Ontario, ×45. (p. 501)

24—Arabellites sp. a. Figured specimen, Olentangy shale, Marsh's Mill, Ontario, ×30. (p. 504)

25—Eunicites? sublamellosus Stauffer, n. sp. Holotype, Widder beds, James Bell quarry, Thedford, Ontario, ×30. (p. 506)

26, 32, 34—Nereidavus ontarioensis Stauffer, n. sp. Syntypes. *26*, Widder beds, Paisley farm, Port Frank, Ontario, ×45; *32*, Ipperwash limestone, Ipperwash Beach, Ontario, ×30; *34*, same place, ×45. (p. 507)

27, 33—Nereidavus inornatus Stauffer, n. sp. Syntypes. *27*, Widder beds, James Bell quarry, Thedford, Ontario; *33*, Ipperwash limestone, Ipperwash Beach, Ontario; ×45. (p. 507)

29—Arabellites productus Stauffer, n. sp. Holotype, Olentangy shale, Marsh's Mill, Ontario, ×30. (p. 504)

30, 37—Arabellites oblatus Stauffer, n. sp. Widder beds, James Bell quarry, Thedford, Ontario, ×30. *30*, Holotype; *37*, figured specimen. (p. 503)

31—Eunicites placidus Stauffer, n. sp. Holotype, Ipperwash limestone, Ipperwash Beach, Ontario, ×45. (p. 506)

35, 36—Protarabellites hamiltonensis Stauffer, n. sp. Paratypes. Widder beds, James Bell quarry, Thedford, Ontario, ×30. *35*, Side view; *36*, top view. (p. 509)

38, 39, 44—Protarabellites canadensis Stauffer, n. sp. *38, 39* Syntype, opposite sides, Olentangy shale, Marsh's Mill, Ontario; *44*, figured specimen, Ipperwash limestone, Ipperwash Beach, Ontario, ×30. (p. 508)

40–42, 50—Arabellites anatinus Stauffer, n. sp. Syntypes. *40, 42, 50*, Widder beds, James Bell quarry, Thedford, Ontario, ×45; *41*, Olentangy shale, Marsh's Mill, Ontario, ×30. (p. 501)

43, 45—Arabellites modestus Stauffer, n. sp. Syntypes, Widder beds, James Bell quarry, Thedford, Ontario, ×45. (p. 503)

46—Arabellites sp. b. Figured specimen, Olentangy shale, Marsh's Mill, Ontario, ×30. (p. 505)

47—Nothrites sulcatus Stauffer, n. sp. Holotype, Olentangy shale, Marsh's Mill, Ontario, ×30. (p. 508)

48—Diopatraites conformis Eller. Figured specimen, Ipperwash limestone, Ipperwash Beach, Ontario, ×30. (p. 505)

49—Arabellites robustus Stauffer, n. sp. Holotype, Widder beds, James Bell quarry, Thedford, Ontario, ×30. (p. 504)

JOURNAL OF PALEONTOLOGY, VOL. 13, NO. 5, PP. 512–513, PL. 59, SEPTEMBER, 1939

TWO UNIQUE SILURIAN CORALS

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ABSTRACT—A study of two authentic specimens of *Desmidopora alveolaris* Nicholson from the Wenlock limestone at Wren's Nest near Dudley, England, has shown that this species is distinctly different from *Multisolenia tortuosa* Fritz from the Lockport formation of Lake Timiskaming, thus proving the validity of the genus *Multisolenia*.

IN A RECENT palaeontological note (1), attention was drawn to the apparent similarity of the two Silurian corals *Desmidopora alveolaris* Nicholson from the Wenlock Limestone (2) at Dudley, England, and *Multisolenia tortuosa* Fritz from the Lockport of Lake Timiskaming (3), and to the possibility of their being congeneric. Since the appearance of this note an opportunity has been afforded the writer of studying two specimens of Nicholson's species with thin sections (Pl. 59 figs. 1–4) of the same from Wren's Nest near the type locality. This study has led to a better understanding of the relationships existing between these two species.

Before discussing these relationships I should like to thank Dr. Dighton Thomas of the British Museum of Natural History for locating the material from England in the Holcroft collection at Birmingham. Also, I should like to express my indebtedness to Professor L. J. Wills of the Department of Geology at the University of Birmingham for very kindly loaning me these specimens, which, in the absence of Nicholson's lost type, are apparently the only known examples of this species.

The genus *Desmidopora* Nicholson, like the genus *Multisolenia* Fritz, is represented only by the species considered in this paper. As *Desmidopora* is not a widely known genus the original description is herein quoted:

> Corallum composite, with an epithecate base, the corallites subpolygonal, and indissolubly united by the coalescene of their walls. The corallites are sometimes circumscribed, but they are for the most part more or less extensively connected by deficiency of their walls in particular directions, so as to give rise to sinuous rows of serially-united tubes. The calices, like the corallites, may be circumscribed, but are mostly in the form of vermiculate grooves corresponding with the serially confluent corallites. The calices are not oblique, nor are the corallites reclined. Mural pores are numerous and well developed. Septa and septal spines are wholly wanting. The tabulae are numerous, being simple and complete in the circumscribed corallites, but becoming vesicular in the rows of serially confluent corallites. New corallites are produced by fission.

It was not until the establishment of the genus *Multisolenia* in 1937 that my attention was drawn to the recently resurrected genus *Desmidopora*. An examination of Nicholson's figures of the genotype led me to think that the two corals might be congeneric. The present study, however, has shown that the two genera are distinctly different, thus proving the validity of the genus *Multisolenia*.

The table (page 513) shows the outstanding characteristics of these two genotypes. From the summary of characteristics in the table it seems evident that these two corals are not genetically related though they furnish an excellent example of homeomorphy (4).

Desmidopora, with its lack of septa or septal spines and its meandering coralites, resembles the genus *Chaetetes*. It differs, however, from the latter genus in the possession of mural pores. The form of the corallum and the character of the mural pores suggest the genus *Alveolites* but, on the other hand, the spiny septa characteristic of that genus are absent. Furthermore, in the latter genus the openings of the coralites are crescentic. In spite of these differences it would seem that *Desmidopora* and *Alveolites* are in the same line of development.

Multisolenia differs from all the above genera with meandering corallites in possessing numerous large connecting tubes, or

CHARACTERISTICS OF GENOTYPES OF MULTISOLENIA AND DESMIDOPORA

	Multisolenia tortuosa Fritz	*Desmidopora alveolaris* Nicholson
Corallum	Stratiform mass nearly 4 cm thick and over 7 cm in diameter.	Laminar expansion 1 to 2 cm thick and one-half foot in diameter.
Corallites	Irregularly prismatic to round; very small $\frac{1}{3}$ to $\frac{2}{3}$ mm in diameter, as many as 13 may occupy the space of 5 mm.	Subpolygonal $\frac{2}{3}$ to 1 mm in diameter, as many as 9 may occupy the space of 5 mm. Some are completely circumscribed by a wall, others are confluent, the latter causing the meandering effect shown on horizontal surfaces.
Walls	Thin, showing a slight line of demarkation, thus indicating their possible integrate nature.	Moderately thick and amalgamate.
Mural Pores	If present, they are exceedingly small and inconspicuous.	Well-defined, large, and numerous.
Reproduction	By fission.	By fission.
Septa	Well developed; spiny.	Absent.
Solenia	Numerous and large; responsible for the peculiar meandering appearance on horizontal surfaces.	Absent.
Tabulae	Closely spaced and arched upward.	Closely spaced; complete in circumscribed corallites, vesicular in confluent corallites.

solenia. According to Bourne the presence of solenia suggests the *Alcyonaria*, and it may be that *Multisolenia* is genetically related to that group of corals.

It would seem that in Palaeozoic times there were many short-lived coral stocks, of which the two herein discussed provide splendid examples, that left behind them only a very meagre record of their origin and development. In the light of our present knowledge it seems wiser to treat such forms as these separately and not to attempt to devise systematic groupings until sufficient data are acquired to establish subdivisions on a sound natural basis.

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JOURNAL OF PALEONTOLOGY, VOL. 13, NO. 5, P. 514, PL. 59, SEPTEMBER, 1939

LICHENARIA COBOCONKENSIS, A NEW CORAL FROM THE ORDOVICIAN OF ONTARIO

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IN THE middle beds of the Coboconk formation (Chaumont) of the Black River group, at Coboconk, Ontario, I found last year what appears to be a new species of the genus *Lichenaria* Winchell and Schuchert. This coral differs from all other species of *Lichenaria* either in the size of the corallum or in the spacing of the tabulae in the corallites. Associated with it in the same bed are *Lichenaria carterensis* (Safford), *Columnaria halli* Nicholson, *Lambeophyllum profundum* (Conrad), and *Stromatocerium rugosum* Hall.

LICHENARIA COBOCONKENSIS
Okulitch, n. sp.
Plate 59 figures 5, 6

Corallum massive, cerioid, irregularly globular or hemispherical, about 4.5 cm. in diameter. Corallites prismatic, more or less irregularly polygonal; mature corallites in most cases six- to eight-sided, younger corallites more often three- or four-sided. Diameter of mature corallites ranges from 1.5 to 1.8 mm.

Walls imperforate. Septa, dissepiments and columella absent. Tabulae complete and flat, not very numerous, and spaced from 1.2 mm to about 5 mm apart. The average spacing is about 2.5 mm.

The new species differs from *L. carterensis* (Safford) in the consistently larger corallites, which are 1.5 to 1.8 mm in diameter instead of 1 to 1.5 mm, and in the spacing of the tabulae, which in *Lichenaria carterensis* are very close together, two to four occurring in a space of 1 mm.

Lichenaria typa Winchell and Schuchert is considerably smaller, the corallum being only about 2 cm in diameter, and the corallites usually about 1 mm or less in diameter.

Horizon and locality.—Coboconk (Chaumont) limestone of Black River group at Coboconk, Ontario.

Types.—Holotype no. 16560 and syntype no. 16561, Royal Ontario Museum of Palaeontology, Toronto, Ontario.

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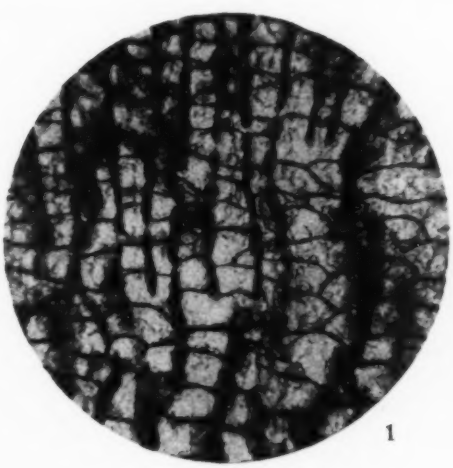
EXPLANATION OF PLATE 59

FIGS. *1, 2—Desmidopora alveolaris* Nicholson. *1*, Vertical section, ×11, showing normal tabulae in the circumscribed corallites and vesicular tabulae in the confluent corallites; *2*, tangential section, ×11, showing the thick-walled circumscribed and confluent corallites, also large mural pores. Sections from specimen no. 430, Holcroft Collection, University of Birmingham, England. (p. 513)

3, 4—Multisolenia tortuosa Fritz. *3*, Vertical section, ×11, showing particularly well the cut ends of the numerous large solenia, also the slightly arched tabulae; *4*, tangential section, ×11, showing the very tortuous corallites, comparatively thin walls, and the spiny septa sparingly developed. Sections from specimen no. 1154, Royal Ontario Museum of Paleontology, Toronto, Canada. (p. 513)

5, 6—Lichenaria coboconkensis Okulitch, n. sp., ×1. *1*, Naturally weathered cross section of holotype, Royal Ontario Museum of Palaeontology no. 16560; *2*, naturally weathered longitudinal section of syntype, no. 16561. (p. 514)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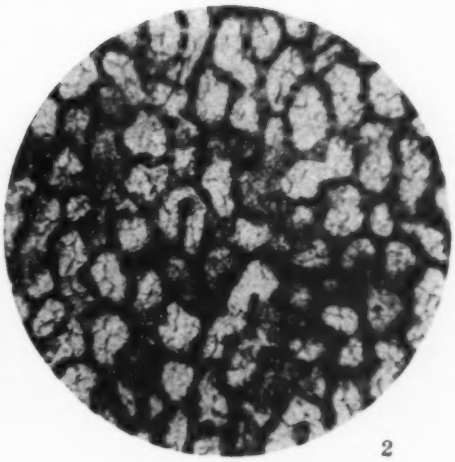
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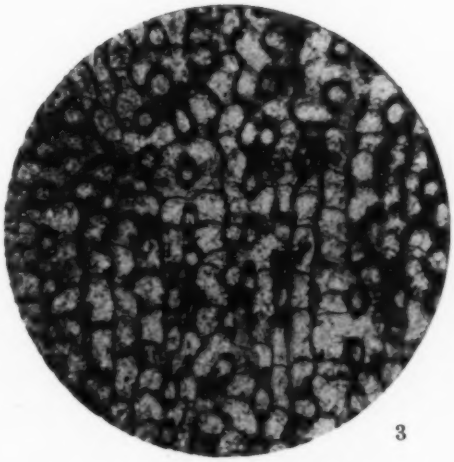
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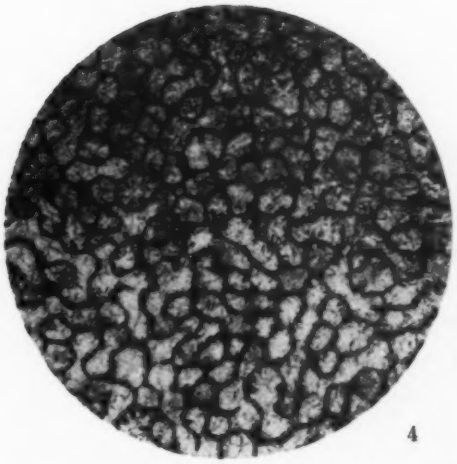
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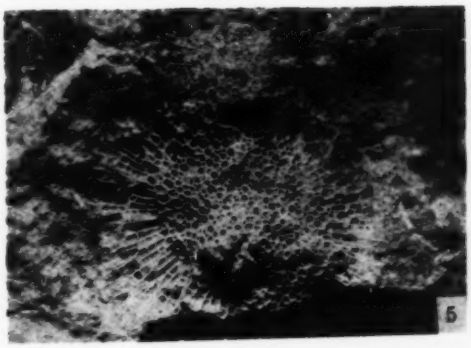
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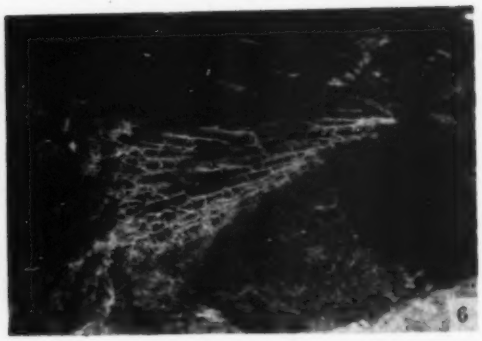
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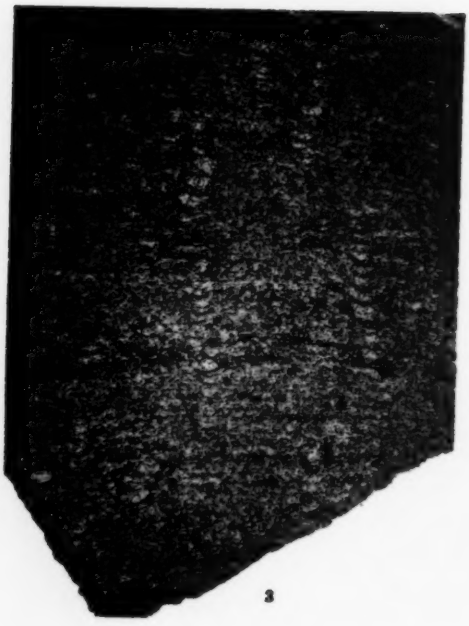
Fritz, Silurian Corals
Okulitch, Ordovician Coral

1

2



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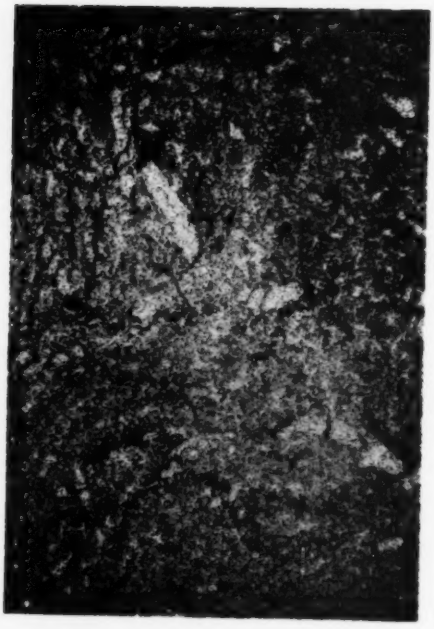

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Johnson and Pfender, *Parallelopora goldfussii*

JOURNAL OF PALEONTOLOGY, VOL. 13, NO. 5, PP. 515–516, PL. 60, SEPTEMBER, 1939

PARALLELOPORA GOLDFUSSII FROM THE DEVONIAN NEAR CODY, WYOMING

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and
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IN 1936–37, Mr. E. H. Stevens collected a number of specimens of supposedly algal limestones, which were given to Mr. Johnson for study. They showed well-developed concentric layers, and in growth habits and general appearance suggested algal colonies of the "Cryptozoon" type, but studies of thin sections proved the organisms responsible to be stromatoporoids. They differed, however, from all the forms described by Parks (1) from the Devonian and by Newell (2) from the Pennsylvanian of North America, but were recognized by J. Pfender as the well-known European type *Parallelopora goldfussii* Bargatzky (3). It is of considerable interest that this species, long known from England and Germany, makes its first recognized American appearance in northwestern Wyoming.

The material was obtained from the top of a small ridge near Paint Creek on the north side of Pat O'Hara mountain, about 20 miles northeast of Cody, Park County, Wyoming, approximately in T. 54 or 55 W., R. 104 W. The specimens were collected near the top of Devonian strata that have been considered by the geologists of the Yellowstone-Beartooth Project to belong to the Three Forks formation. According to Mr. Stevens, the outcrop of the fossil-bearing horizon is small, being only a few feet wide on a steep slope. He states that the colonies of *Parallelopora* were very abundant at the one horizon, occurring as flattened separate heads. Local crowding caused several to grow together, but he did not observe anything suggestive of a "reef" or similar concentration of growth.

The specimens are of large size, some attaining dimensions of 20 by 30 by 18 cm (fig. 1). They represent flattened cabbage-like or egg-shaped colonies composed of arched or concentric layers (pl. 60, fig. 1). The layers are in general thin (1 to 3 mm), and their surfaces are free from "mamilons" or other projections. The texture is very fine, few of the structural details being visible to the naked eye with the exception of the lamination. The areas of attachment on the base are quite small (about 8 cm in diameter on a specimen having a diameter of 19 cm). No epitheca appears to be present; astrorhizae occur but are inconspicuous and of small size.

The skeleton fibre is plumose, like that of *Stromatopora*, but with the porous tubular appearance which is one of the characteristics of the genus *Parallopora*. The coenosteum is constituted of vermicular elements and tabulated tubes arranged in a slightly irregular reticulate pattern (pl. 60, fig. 2) with isolated clear spaces of relatively large size within the substance of the fibre. The material is so crystallized as to make exact measurement difficult, but the elements of the skeleton fibre show a general range in diameter between 100 and 190 microns; the majority are about 160. A few are as small as 80 microns. This is close to that given by Nicholson (4, p. 192) for

EXPLANATION OF PLATE 60

FIGS. *1–4—Parallelopora goldfussii* Bargatzky. *1*, Specimen showing several colonies, ×0.34; *2*, tangential thin section, ×7.5; *3*, vertical section showing zooidal tubes with tabulae, ×7.5; *4*, tangential section showing perforations and the branches of the astrorhizas with the cross partitions, ×7.5. (p. 516)

P. goldfussii (160–200μ) though slightly larger. Between these fibres the spaces are filled with crystalline calcite and are very similar to the forms figured by Nicholson (4, pl. 25, figs. 4, 5) and Bargatzky (3).

In tangential sections (pl. 60, figs. 2–4) the irregularly reticulate skeleton fibre is cut by irregularly spaced branches of the astrorhizas, which are commonly cut by curved cross partitions or tabulae (pl. 60, fig. 2); the surface is pierced also by the variously shaped apertures of the transversely divided zooidal tubes.

Vertical sections show the skeleton to be composed of numerous thick rods and pillars and horizontal elements. The fine network so formed encloses relatively coarse zooidal tubes. These tubes are arranged vertically and show well developed tabulae, many of which are curved. The tubes range in diameter between 200 and 500 microns, sometimes attaining a size as great as 800 microns. They are spaced irregularly up to a maximum of about 2 mm (pl. 60, fig. 3). The tubes are longer, more numerous, and spaced closer together than in *Stromatopora*.

The concentric banding is clearly visible on both the hand specimens and the tangential thin sections (pl. 60, figs. 1, 2).They correspond to the latilaminae of Nicholson, having an average width of 1 to 2 mm.

These characteristics fit well the description given *Parallelopora goldfussii* by Bargatzky (3, p. 6), and restated by Nicholson (4, pp. 191, 192, 194, 195, pl. 25, figs. 4, 5), in that the essential features of the genus *Parallelopora* are a coarsely reticulated fibre, vertical pores, and peculiar vertical vacuities or rodlike bodies in the mass of the fibre. The detailed measurements indicate the species *goldfussii* quite closely, all being well within the widely varying extremes given by Nicholson.

The genus *Parallelopora* is known chiefly from the Devonian, essentially middle Devonian. It has been recorded as being fairly common in the middle Devonian limestones of the Paffrath district of Eifel, Germany, and rarely in the Devonian of Devonshire, England. In the collections of Yvonne Dehorne at the Sorbonne, there are specimens and slides of *Parallelopora capitata* Goldfuss from the Ardennes region of France, which were used for comparison with our form.

This genus has not been previously recorded from the Devonian of North America. Newell (2) has described a species, *Parallelopora mira*, from the Pennsylvanian of Kansas, and Yabe and Sugiyama (5) have noted a species, *Parallelopora minoensis*, from the lower Permian of Japan.

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Note: Manuscript received by the Editor March 15, 1939.

JOURNAL OF PALEONTOLOGY, VOL. 13, NO. 5, PP. 517–520, 4 TEXT FIGS., SEPTEMBER, 1939

TEREBRATULINA KUGLERI, N. SP., FROM THE EOCENE OF SOLDADO ROCK

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THE SMALL island of Soldado Rock lying midway between Trinidad (B.W.I.) and the mouth of the Rio Pedernales (Venezuela) has, as a result of the publications of Carlotta Joaquina Maury, H. Douvillé, A. Jeannet, H. G. Kugler and others, become one of the most important starting points for stratigraphical investigations in the Paleogene of tropical America.

Since the appearance of these publications, the writer has studied the extensive collections from Soldado Rock made by the geologists of Trinidad Leaseholds, Ltd. These investigations prove conclusively that on Soldado Rock there are two totally different molluscan faunas. The older one corresponds to Maury's (1912) "bed no. 2" and to Kugler's (1923) "Kalksteinkomplex A"[1] This represents the type fauna of the Soldado formation of Maury (1925). The following is a selected list of important species which I have determined from this fauna:

SPECIES OF THE SOLDADO FORMATION

Cucullaea (*Latiarca*) *harttii* Rathbun,
Venericardia aff. *parinensis* Olsson,
Venericardia cf. *ameliae* Peron,
Callista (*Costacallista*) *rathbunensis* Maury
Mesalia scotti n. sp.,
Mesalia aff. *nettoana* White,
Turritella (*Torquesia?*) *elicitatoides* Maury,
Turritella sylviana Hartt?,
Calyptraphorus velatus compressus Aldrich,
Cypraea (*Eocypraea*) *bartlettiana* Maury,
Mandolina (*Archicypraea*) *trinidadensis* Schilder
Priscoficus johnstoni n. sp.,
Pseudoliva bocaserpentis Maury,
Athleta (*Volutocorbis*) *pariaensis* Maury,
Hercoglossa cf. *harrisi* Miller and Thompson.

This fauna, which in Trinidad is represented by the Marac quarry fauna (Marac formation Harris, 1926) is undoubtedly of old Paleocene age and is not equivalent to the Wilcox as assumed formerly by Vaughan and the writer (Rutsch, 1936) but to the Midway of the southeastern United States (probably Kincaid formation of Texas?) as already asserted by Maury as early as 1912. It bears some striking affinities to Upper Cretaceous mollusks from Northern Africa and from the East Indies,[2] which give it an archaic aspect, considering that it is of Paleocene age. On the other hand it has affinities to the Maria Farinha fauna of Brazil and to the Midwayan of the southeastern United States.

The younger of the two molluscan faunas corresponds to bed 8 of Maury (1912) and to Kugler's (1923) Kalksteinkomplex C (bed 11 of Kugler, 1938) and represents the type fauna of the Boca de Serpiente formation of Maury (1929). The following mollusks, among others, have been determined by the present writer: *Liothyrina stantoni* (Maury), *Tubulostium leptostoma clymenioides* (Guppy), *Rimella* (*Ectinochilus*) *knappiana* Maury, *Terebellum* aff. *procerum* Merian, and *Pachycrommium smithianum* (Maury).

The Boca de Serpiente formation has been correlated by Maury (1912) with the Wilcox, by Kugler (1938) tentatively with the Oligocene, and later, by Maury (1929, 1935) with the Ludian. Re-examination of the mollusks has shown that in all probability the Boca de Serpiente formation may be correlated with the fauna from Vista-bella quarry on Mount Moriah in Trinidad and that it is definitely younger than Wilcox but older than Vicksburg. Its age is probably Jacksonian (upper Eocene).

Now, between the Boca de Serpiente formation, above, and the Soldado formation below, there lies yet another mollusk-bearing horizon in the Soldado Rock section, styled bed 6 by Maury (bed 10 of Kugler,

[1] Bed no. 2 of Kugler (1938).

[2] Thus, for instance, the Marac quarry fauna has yielded a *Campanile* that shows close affinities to a species described by Douvillé from the Upper Cretaceous of Luristan.

1938). Unfortunately this bed has yielded no determinable mollusks. According to Gorter and Van der Vlerk (1932) this bed contains the Foraminifera *Lepidocyclina pustulosa* H. Douvillé, *Lepidocyclina* (*Pliolepidina*) *tobleri* H. Douvillé, *Discocyclina* (*Asterocyclina*) *asteriscus* (Guppy), and *Camerina floridensis* Heilprin.

From bed 6 (bed 10 of Kugler, 1938) Jeannet (1928) described the echinoids *Oligopygus kugleri* Jeannet, *O. zyndeli* Jeannet, *O. christi* Jeannet.

Moreover bed 6 yielded the specimens of *Terebratulina kugleri* Rutsch, n. sp., described herein. They were found by Dr. H. G. Kugler, and presented to the Museum of Natural History at Basel (Switzerland). Paratypes have been forwarded to the Geological Department of the British Museum (Natural History) in London. This brachiopod commands special interest because representatives of the genus *Terebratulina* are very rare in the Tertiary of America. To my knowledge these Soldado Rock specimens are the first representatives of the genus in the Eocene of tropical America. A. O. Thomas (1921) mentioned a *Terebratulina* from the Oligocene of Antigua. Unfortunately his statements were limited to a very short abstract, which here follows in full:

> In the Antigua limestone at Half Moon Bay, Antigua, there occurs an abundance of lepidocycline Foraminifera, a number of sea-urchins, some corals, pelecypods, a few gastropods, and rarely some brachiopods belonging to the genera *Argyrotheca*, *Terebratulina*, and *Liothyrina*. They appear to be new species, though the Liothyrinas are close to those reported by Guppy from Trinidad over fifty years ago. These small forms have added interest since very little is known about the brachiopods of the American Oligocene.

An accurate knowledge of the fossils of the Soldado Rock is of great importance on account of their bearing on regional stratigraphic correlation.

SYSTEMATIC DESCRIPTION

Genus TEREBRATULINA d'Orbigny, 1847

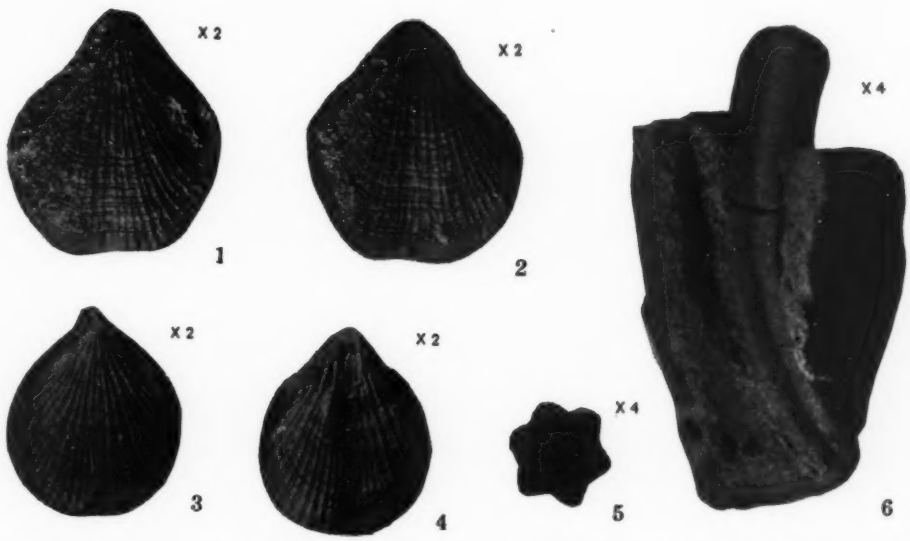
Genotype: *Anomia caputserpentis* Linné = *retusa* L.

TEREBRATULINA KUGLERI
Rutsch, n. sp.
Text figures 1–4

Shell of the holotype 17 mm long, 14.8 mm wide and 6 mm thick, capillate, inequivalve, very slightly convex, ovate or irregularly pentagonal. Some specimens show a slight longitudinal depression on each valve, beginning at about the half the length of the shell and extending to the anterior commissure. Beak truncated by the foramen, deltidial plates not observable. The ornamentation of the surface consists of sharp, narrow, fine, radiating costae, separated by very broad interspaces. These costae increase in number by intercalation, or, more rarely, by bifurcation. They bear rather strong nodes, which, even in adult specimens, persist from the beak to the anterior commissure. Strong growth lines cover the shell. About 20 specimens.

Remarks.—As the important features of the foramen and the internal structure are not observable in our specimens, identification with one of the species of *Terebratulina* so far known would appear to be impossible. However, I have compared them with several specimens of *Terebratulina lachryma* from Charleston (South Carolina) and from Choctaw Co. (Alabama) which were kindly sent me by Dr. W. P. Woodring. *Terebratulina lachryma* (Morton) is more convex, has finer, closer-spaced radiating ribs, which are separated by much smaller interspaces. The nodes of *T. kugleri* are missing in full-grown specimens of *T. lachryma*. *Terebratulina lachryma* (Morton) seems to be confined to the Jacksonian of the United States. Cooke (1915, 1917, 1926) mentions it from several localities in the Jacksonian (Ocala limestone) of Alabama and Florida, where it is associated with several species of *Discocyclina*. As far as I know, this is the only species of *Terebratulina* from the Paleogene of the Atlantic coast of North America. *Terebratulina innovata* De Gregorio, which, according to De Gregorio (1890), is probably derived from Claiborne, is of unknown origin according to Dall (1903, p. 1540).

The Oligocene representative recorded by Thomas from Antigua has already been mentioned. Trechmann (1937, p. 354) cites *Terebratulina* "*caputserpentis* L." from the Neogene of Barbados and from the Manchioneal beds (Pliocene) of Jamaica (1930, p. 214). Another representative of the genus seems to occur in the Cretaceous of Jamaica (Trechmann, 1927, p. 34).



FIGS. *1–4—Terebratulina kugleri* Rutsch, n. sp. Bed 10, Soldado Rock, Gulf of Paria, Naturhistorisches Museum, Basel, Switzerland, type no. 305. Dorsal and ventral views of two individuals, ×2. *1*, Holotype; *3*, *4*, paratype. (p. 518)
5, *6—Hamulus onyx* Morton. Upper Cretaceous, Bontour Point, Trinidad, B.W.I. Basal and side views, ×4. Naturhistorisches Museum, Basel, Switzerland, no. 297. (p. 521)

From the numerous representatives of *Terebratulina* in the Paleogene of Europe I will first mention *Terebratulina wardenensis* Elliott (= *T. striatula* J. de C. Sowerby, not of Mantell) from the London Clay (Ypresian) of England. I am greatly obliged to Dr. Helen M. Muir-Wood (London) for sending me several specimens of *T. wardenensis* from the Isle of Sheppey. This species differs from *Terebratulina kugleri* in the following features: Its radiating ribs are much more closely spaced, the nodose character of the ribs disappears in full-grown specimens of *T. wardenensis* whereas it persists in *T. kugleri*.

A careful study of *Terebratulina wardenensis* has recently been published by Mr. G. F. Elliott (1938). Similar distinguishing characteristics separate our species from the form described as *Terebratulina striatula* from the Eocene of Northern Italy. Owing to the kindness of Dr. W. O. Dietrich in Berlin I have been able to compare specimens from Castelcies. This form, according to Oppenheim (1900), Fabiani (1914) and others, makes its first appearance in the Spilecciano (Yprésien) and continues through the Lutetiano and Priaboniano into the Lattorfiano. All the *Terebratulinas* from the Paleogene of the Paris Basin (Cossmann and Pissarro), Belgium (Vincent), Northern Germany (von Koenen) and from Kressenberg which I was able to compare, differ from our type. Another species to be compared with *Terebratulina kugleri* is *Terebratulina tenuistriata* (Leymerie) which has been carefully described and figured by Doncieux (1905, 1926). My thanks are again due to Dr. Helen M. Muir-Wood for specimens of *T. tenuistriata* from Las Lanes west-southwest of Fontcouverte, Aude. These specimens have more numerous, closer-spaced ribs, which are not nodose in the adult stage, they lack the longitudinal depression in the middle of the valves.

The age of *Terebratulina kugleri* is certainly Eocene. According to the Foraminifera associated with our species it is probably Jacksonian (upper Eocene). A study of these foraminifera by Dr. T. Wayland Vaughan will appear in due course.

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JOURNAL OF PALEONTOLOGY, VOL. 13, NO. 5, PP. 521–523, 2 TEXT FIGS, SEPTEMBER, 1939

UPPER CRETACEOUS FOSSILS FROM TRINIDAD, B.W.I.

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ABSTRACT—A sandstone block from the Eocene conglomerate at the San Fernando-Bontour Point section of Trinidad has yielded the tubicolar annelid *Hamulus onyx* Morton and fragments of the ammonite *Sphenodiscus* sp. ind. These indicate that the rock from which they came, for which the name *Hamulus* sandstone is proposed, is of Upper Cretaceous age. A bibliography of Cretaceous fossils of Trinidad is appended.

CRETACEOUS fossils from Trinidad, British West Indies, have been known since the investigations of Wall and Sawkins in 1860. Since then a great many authors have contributed to our knowledge of the organic remains, which as a rule, are not very abundant in the Cretaceous strata of Trinidad. The appended bibliography includes all the papers on the morphology and the systematic and biostratigraphic significance of the Cretaceous fossils from Trinidad that have come to my attention.

In 1926 Harris described an interesting fauna from what he called "Bontour formation" of Bontour Point on the west coast of Trinidad. According to Harris this fauna has a sufficient number of elements in common with the late Cretaceous of northern Africa to admit of fairly definite correlation. It includes *Roudairea auressensis bontourensis* Harris, *Ostrea tripolitana* Krumbeck, and *Psilomya bontourensis* Harris. According to Kugler (1936) it was found in blocks of calcareous sandstone included in the basal conglomerate in the Eocene of the famous San Fernando-Bontour Point section.

Other Upper Cretaceous fossils have since been found by Drs. H. G. Kugler and E. Lehner in a block of a different kind at Bontour Point and forwarded to the Museum of Natural History at Basel. This block has not only yielded the first ammonite of undoubted Upper Cretaceous age ever to be found in Trinidad, but besides, also permits direct correlation with the Upper Cretaceous of the southeastern United States. It consists of rather hard glauconitic rather fine grained gray sandstone weathering light brown. It contains numerous fossil mollusks, fish teeth, and minute fragments of bones. Some well-preserved shark teeth have been sent to Prof. Maurice Leriche of Brussels for examination. Most of the mollusks are too poorly preserved for even generic determination, but among them are better preserved specimens of the tubicolar annelid *Hamulus onyx* Morton and an unidentified species of the ammonite genus *Sphenodiscus*. The presence of these two fossils suffices for an age determination. As *Hamulus onyx* has not heretofore been reported from the West Indies a description and figures are given.

HAMULUS ONYX Morton

Text figures 5 and 6, p. 519

Hamulus onyx MORTON, *1834*, Synopsis of the organic remains of the Cretaceous of the United States, p. 73, pl. 2, fig. 8: pl. 16, fig. 5. —GARDNER, *1916*, Maryland Geol. Survey, Upper Cretaceous, p. 747.—WADE, *1921*, U. S. Nat. Mus., Proc., vol. 59, p. 43, pl. 9, figs. 1–3, 5, 6.—STEPHENSON, *1923*, North Carolina Geol. Survey, vol. 5, p. 76, pl. 10, fig. 11.—WADE, *1926*, U. S. Geol. Survey, Prof. Paper 137, p. 30, pl. 2, figs. 4–7, 12.

Tube rather strong, slightly curved, very similar to that of *Dentalium*, with six prominent, angular, subequal, longitudinal (axial) ribs extending from base to apex. Aperture circular, contracted. Operculum not preserved. Incremental lines obscure. Nucleus broken away. Length of largest specimen, exclusive of the curve, 23 mm.

Remarks.—This tubicolar annelid was originally described by Morton from Erie, Alabama, and from Lynch's Creek, South Carolina. It is widely distributed in deposits of Santonian and Maestrichtian ages, zones of *Exogyra ponderosa* and *E. costata*, in the southeastern United States, but has

not previously been reported from elsewhere. Its distribution is given by Stephenson (1923*a*). Through the kindness of Dr. W. P. Woodring I have compared the specimens from Trinidad with several from the Ripley formation of Coon Creek, Tennessee, with which they agree perfectly.

Occurrence.—Five specimens from locality 35, Bontour Point, Trinidad. Figured specimen, no. 297, Naturhistorisches Museum at Basel, Switzerland.

SPHENODISCUS sp.

Regarding the two fragments of ammonite I am indebted to Prof. O. Seitz for furnishing me with the following data:

> The two ammonite fragments belong to *Sphenodiscus*. The smaller, phosphorized fragment shows parts of the interior sutures. The shape of the saddles is recognizable only in a few places and then in the earlier parts of the cast, but is characteristic of *Sphenodiscus*. The larger fragment has an acute external side and in this respect also resembles *Sphenodiscus*. Under the circumstances little can be stated regarding the sutures. *Sphenodiscus* is known from Campanian and Maestrichtian.

In the United States, according to Stephenson (1923, p. 48; 1933, p. 1357), *Sphenodiscus* ranges from the upper part of the *Exogyra ponderosa* zone through the *Exogyra costata* zone (Upper Campanian through Maestrichtian). Hedberg (1937) reports *Sphenodiscus* from the Rio de Oro formation of eastern Colombia and western Venezuela on the authority of L. F. Spath, who says that there is no doubt as to the Maestrichtian age of the fauna. Another representative of the genus *Sphenodiscus* in Venezuela, determined by Aug. Tobler as *Sphenodiscus lenticularis* Hyatt, has been described by L. Kehrer (1937) from the Upper Cretaceous Colon shales from Rio Lobaterita, northwest of Colon. Stephenson (1939) suspects that this species may represent instead the similar genus *Coilopoceras*, for the Colon shale lies well below the known range of *Sphenodiscus*.

Further investigations may prove whether any closer relations exist between the Rio de Oro formation and the sandstone of Bontour Point, which has yielded the specimens of *Hamulus onyx*. I propose to give to this sandstone the name of Hamulus sandstone.

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JOURNAL OF PALEONTOLOGY, VOL. 13, NO. 5, PP. 524–525, 1 TEXT FIG., SEPTEMBER, 1939

A NEW AND EARLIER OCCURRENCE OF THE EDRIOASTEROID GENUS HEMICYSTITES

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ABSTRACT—*Hemicystites eckeli*, a new species of Edrioasteroid recently collected from the Murfreesboro formation of lower Stones River age in Lee County, southwestern Virginia, indicates a broader stratigraphic range for this genus than heretofore known. The almost perfect preservation of the specimen permits a more complete description of the species of this genus than has been previously given.

TO DATE very few if any species of the class Edrioasteroidea of the phylum Echinodermata have been described from formations of Stones River age. The excellent preservation of this specimen adds to the knowledge of morphology of this rather complicated group of organisms.

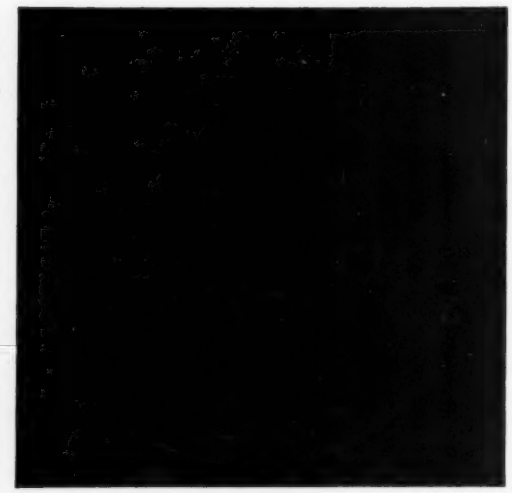

FIG. 1—*Hemicystitse eckeli* Cullison and Prouty, n. sp. Oral side of holotype, ×3.

The writers are indebted to the Tennessee Valley Authority for permission to publish this description of the specimen collected by Robert A. Laurence during their investigations in the Norris Reservoir area; and to Dr. R. S. Bassler of the United States National Museum for preparing the photograph and comparing the specimen with those available at the museum.

SYSTEMATIC DESCRIPTION

Class EDRIOASTEROIDEA Billings, 1854–1858
Family AGELACRINITIDAE Bassler, 1935
Genus HEMICYSTITES Hall, 1852
HEMICYSTITES ECKELI Cullison and Prouty, n. sp.
Text figure 1

Theca, a flattened disc, 18.5 mm in diameter, an integral part of the limestone with no apparent attachment to any preexisting shell. Ambulacral rays five, essentially straight when undistorted, length averaging 6 to 7 mm, width at distal end 1 mm, width at oral end 2 mm, consisting of four rows of covering plates of two distinct types. The more prominent and larger covering plates are generally elongated and roughly pentagonal in outline and so arranged in pairs as to interlock along the median line. Frequently but with no apparent regularity the distal ends of some of these are bifurcated into a shallow notch so as to facilitate the interlocking. Lying on both sides of the median line of each ambulacrum there is a row of small covering plates, which are generally rhombic in outline. These plates are located between the distal tips of the larger plates, with which they alternate along the median line. They decrease in size and prominence towards the distal ends of the ambulacral rays. The rays are variously curved in this specimen as follows: I, curvature slightly

contrasolar; II and III, straight; IV, curvature contrasolar; and V, curvature solar. The writers believe that the curvatures of the ambulacra are mostly due to slight distortion. The ambulacral system of the specimen agrees with Foerste's (1914) views concerning the trimerous origin, in that rays I and II and rays IV and V branch dichotomously from a common ray at a distance of about 1 mm from the center, whereas ray III has its origin at the center. Anal area large, distinct, lying between rays I and V, composed of a single cone of at least eight (only six are preserved) rather large triangular plates, which have their smaller angle at the apex of the cone. Interambulacral plates large, few, and uniformly imbricating towards the oral area. At the distal end of rays I, II, III, and IV, in areas which are not so much distorted, such as the area at the end of ray V, the ambulacral rays terminate in a large V-shaped notch, which occurs in a plate similar to the interambulacral plates. Plates along the peripheral margin are more numerous, much smaller and less uniformly imbricating.

This species is most similar in general characteristics to *Hemicystites chapmani* (Raymond) (1921) but differs from it in having the two additional rows of minute rhombic cover plates on the ambulacra, in having the large plate with the V-shaped notch at the end of each ray, having more massive and comparatively shorter ambulacra, and in having only one distinct circle of anal plates.

Occurrence.—In the upper 30 feet of the Murfreesboro formation of lower Stones River age on road along Yellow Branch, 5.5 miles southeast of Rose Hill, Lee County, Virginia.

Holotype.—7121, Paleontological collections, Missouri School of Mines and Metallurgy.

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A SKULL OF OSTEOBORUS VALIDUS FROM THE EARLY MIDDLE PLIOCENE OF TEXAS

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ABSTRACT—*Osteoborus validus* Matthew and Cook is here described from an almost perfect skull from the early middle Pliocene Higgins fauna of Texas. Measurements are given, and attention is called to the relationships and differences between this form and other members of the genus *Osteoborus*.

THE CANID skull described in this paper was discovered and presented to the West Texas Historical Museum by Mr. Carl Goettsche. The specimen came from locality 24A of Reed and Longnecker (1932) on the Sebits Ranch in the southeast corner of Lipscomb County, Texas. Mr. Sebits has kindly granted permission to the West Texas State College to work this locality, and during the past year much fine material has been collected through the coöperation of the Works Progress Administration.

The writer wishes also to express his appreciation to Professor R. A. Stirton of the University of California for his permission to make comparative studies of this fossil with type material in the University of California Museum of Vertebrate Paleontology.

OSTEOBORUS VALIDUS Matthew and Cook
Text figures 1–8

Material: An almost complete skull, West Texas Museum no. 1100. The skull is not distorted. The parts that are missing are as follows: tympanic bullae; the left third of the lambdoidal crest; the ventral extremities of the pterygoids; all of the incisors except I^3 on the left side; both canines; P^{3-4}, and M^1 on the left side; and P^3 and M^1 on the right side. The extremities of the postorbital processes of the frontals are also missing. In addition to the skull are the parts of two lower jaws (figs. 4–5) containing the lower dental series P_1–M_1; and an upper jaw (fig. 7) containing P^2, P^4, and M^1; a complete radius (fig. 8), and the distal end of a humerous (fig. 6).

Occurrence: Sebits Ranch, southeast corner of Lipscomb County, Texas, three miles from the south line of the county, and one-quarter mile from the east line. Found in gray unconsolidated fluvial sand, which Stirton (1936) correlates with the early middle Pliocene Ogallala formation, associated with the Higgins fauna.

Diagnosis: *O. validus* differs from other known species of the genus *Osteoborus* by its greater size and massiveness. The muzzle is broad, and the frontal region so developed as to present a high convex surface. The orbits are small; the sagittal and lambdoidal crests well developed; and the brain case but slightly inflated. The skull is proportionately broad across the zygomatic arches in comparison to its length, the ratio of width to length being 67.3 per cent. The anterior cusp, or parastyle, is present on P^4, but the anterior internal cusp is absent. The first, second, and third premolars are relatively small and uncrowded, with the central cusp showing the most prominent development. The palate is broad, and there is a space of 7 mm between the third incisor and the canine. The most powerfully developed teeth of the series are the third incisors, the canines, P^4, and M^1. M^2 is present but vestigial.

Attention should also be called to a pathological condition in the skull. At the posterior end of the left frontal on a level with the postorbital process, there is a depression in the skull 30 mm by 16 mm wide and 13 mm deep. It is healed over inside and apparently is the result of an accident that happened before the animal's death.

FIGS. *1, 2—Osteoborus validus* Matthew and Cope. *1*, Dorsal view, ×0.42; *2*, palatal view, ×0.41

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4

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FIGS. *3–8—Osteoborus validus* Matthew and Cope. *3*, Lateral view, ×0.35; *4*, labial view of anterior part of right ramus, ×0.43; *5*, lingual view of left ramus, ×0.43; *6*, distal end of humerus, ×0.43; *7*, part of left upper jaw, ×0.43; *8*, radius, ×0.43.

CRANIAL MEASUREMENTS (mm)

Length of skull (median incisive border to posterior margin of lambdoidal crest)	315	Width of palate between anterior inner margins of P^4	77
Breadth across zygomatic arches	212	Length of palate from anterior margin of postpalatal notch to median incisive border	145
Vertical diameter of orbit	35	Maximum width of postpalatal notch	38
Width at anterior ventral margins of orbits	108	Distance from line through postorbital processes to posterior dorsal extremity of skull	177
Width at external alveolar borders of canines (estimated)	79	Distance from intersection of temporal impressions to posterior margin of nasals	85
Width at internal alveolar borders of canines	50	Width of palate between posterior inner margins of P^4	96
Maximum transverse diameter of brain case	70	Vertical diameter of external auditory meatus	9
Length of sagittal crest (intersection of temporal impression to lambdoidal crest)	109	Height of lambdoidal crest above foramen magnum	63
Length of nasals	98		
Transverse diameter of external nares	50		
Breadth across occipital condyles	60		
Transverse diameter of foramen magnum	25		
Vertical diameter of foramen magnum	19		

DENTAL MEASUREMENTS, UPPER JAW (mm)

	C	P^1	P^2	P^3	P^4	M^1
Anteroposterior	25	10	16.5	20	40	20
Transverse	17	7	9	10	20	28

Length of dental series; P^1-M^2, 106

DENTAL MEASUREMENTS, LOWER JAW (mm)

	C	P_1	P_2	P_3	P_4	M_1	M_2
Anteroposterior	19	7	10.8	14.9	26.1	40.5	17.5
Transverse	17.5	6.5	8.2	9.6	14.4	17.4	8.5

Length of dental series P_2-M_2, 117 mm.

Dental characters: The teeth present in the skull on the right side of the jaw are P^1, P^2, and P^3 (broken); P^4 on the left, I^3, P^1 and P^2. The alveolae, however, are well preserved, and in the above table the measurements on C, and M^1 are alveolar measurements. The third incisors are large and much more powerful than the others. The canines are large, with no diastema between them and P^1. There is no crowding of the teeth, and there are short spaces between the premolars.

Measurements on M_2 are alveolar measurements.

Dental formula: 1—4—2
1—4—2—3?

Depth of lower jaw below M_1, 54 mm; thickness at this point, 21.8 mm.

M_1 is not present in the skull, but in specimen no. 1796, fig. 6, it may be seen with a strongly developed protocone, which is pointed slightly in a posterior direction. Both paracones and metacones are well developed, although the paracone is much stronger than the metacone. Anteroposterior diameter of M^1, 22.9 mm; transverse, 30.4 mm. M^2 is not present, but as indicated by the alveolus it was vestigial.

There is slight indication that M_3 may also have been present as a vestige, but this is questionable.

The radius (fig. 8): This is a strong bone 304 mm in length; transverse diameter at distal end, 63.3 mm; at proximal end, 42.9 mm; at mid section, 38.8 mm. The radius is thus considerably larger and stronger than that of *Smilodon californicus*.

The humerus (fig. 6): Referred to this species also is the distal end of a humerus, which is 90.2 mm in transverse diameter, with a transverse width across the articular surface of 62.6 mm.

Relationships: The genus *Osteoborus* was described by Stirton and VanderHoof (1933) and *Hyaenognathus cyonoides* Martin from the Edson beds of Sherman County, Kansas, was taken as the genotype. Other material from the middle Pliocene Hemphill beds of Texas previously referred by Matthew and Stirton (1930) to *Borophagus* was also placed in this genus. VanderHoof (1936) redescribed Cope's type of *B. diversidens*

from the upper Pliocene of Mount Blanco and pointed out the identity of this form with the genus *Hyaenognathus* described by Merriam (1903).

The genus *Osteoborus* from the middle Pliocene is closely related to the late upper Pliocene *Borophagus* of Texas and California. In the latter genus the parastyle on P^4 is reduced almost to the vanishing point, whereas it is present and tends to be rather well developed in *Osteoborus*. In both genera the frontal region is high and convex, the head relatively broad and short, as is also the palate. Premolars anterior to P^4 are reduced in size, and the central cusp on the upper premolars 1–3 is prominent in *Osteoborus*, though the anterior and posterior cusps are small and may be absent.

Aelurodon haydeni validus Matthew and Cook (1909) is based upon a lower jaw with P_4-M_2 complete, from Nebraska. It was the writer's privilege to study a lower jaw fragment in the University of California collection, no. 31517, from the Higgins locality, which was identified by Mr. Curtis J. Hesse with the above-mentioned specimen from Nebraska. Hesse places the Higgins specimen in the genus *Osteoborus*. *Aelurodon aphobus* Stock from the Ricardo was referred by Stirton and VanderHoof (1933) to their new genus *Osteoborus*, and given the specific name *ricardoensis*. This form is close to the *O. validus*, but is slightly smaller and differs from it also in several other respects, such as the absence of the posterior accessory cusp on P_3 and a heavier posterior accessory cusp on P_4 than in *O. validus*.

It was further noted in this paper that *A. haydeni validus* was not a true *Aelurodon*. It is on the basis of these facts to which Hesse has called attention in an unpublished manuscript, that the Higgins skull is here placed in the genus *Osteoborus* and assigned to the species *validus* of Matthew and Cook.

Attention should also be called to the fact that, as Stirton has pointed out (personal communication), there is more variation within the species *O. cyonoides* from Hemphill County, Texas, than there is between the Higgins specimen and that from Nebraska.

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COMPARISON OF THE SILICEOUS SPONGES ARMSTRONGIA CLARKE, 1920, AND TITUSVILLIA CASTER, 1939

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SINCE the appearance of my paper (Caster, 1939) dealing with new siliceous sponges from Mississippian and Devonian strata of the Penn-York Embayment, Dr. Charles Butts has called my attention to J. M. Clarke's branching siliceous sponge *Armstrongia*, with which I omitted comparison when describing my new genus *Titusvillia* of similar habitus because I had overlooked the paper in which Clarke (1920) made *Ceratodictya oryx* the genotype of *Armstrongia*.

In my paper (p. 8) it was pointed out that *Ceratodictya oryx* Clarke, 1918, from the "Chemung group" near Erie, Pennsylvania ("9 miles south of Erie, Pa.," Clarke, 1920) is:

> . . . remarkably similar to *Titusvillia*, especially the specimen figured by him (Clarke, 1918) on the right hand side of his plate 2, but (his specimen) shows no evidence of colonial growth, more regular duplication of annulations, and less prominent cuplike development of the nodes, as well as no evidence of a thickened wall condition. If only external molds were found, however, this last statement is hardly justified (proven not justified by Clarke's 1920 figure). *Ceratodictya oryx* shows no reversal of the direction of the component nodes or cups and appears to have a more regular reticulum than *Titusvillia*. Better material may show that *Ceratodictya oryx* is a Devonian form of the Titusvilliidae.

By the present note I wish to reaffirm my previous prognostication, which would have been unnecessary had I discovered Clarke's 1920 paper, and point out that this supplementary material proves beyond doubt that *Armstrongia oryx* (Clarke) is, as I suggested, the Upper Devonian antecedent and probable lineal ancestor of *Titusvillia drakei* Caster in the Mississippian of the same Embayment.

The reader is referred to my analysis (p. 1) of the new family Titusvilliidae for the criteria by which it seems advisable to consider *Armstrongia* and *Titusvillia* as members of the same family of the Lyssacina. So far as can be judged from Clarke's (1918, 1920) descriptions and illustrations of his species, it differs in no essential family trait from *Titusvillia*. Clarke's (1920) elaborate figure shows very well the presence of two reticular nets and a "felted" intermediate zone of spicules, and particularly the branching, supercolonial mode of growth. Both genera differ in the same features from the Dictyospongiidae to which most previously described siliceous sponges of the Paleozoic have been referred.

Why consider *Titusvillia* and *Armstrongia* as distinct genera? As I visualize generic characters in the new family, mode of branching and especially regularity of branching, shape of individual cups or nodes and their degree of uniformity in the individual colonies and supercolony, and the presence or absence of the feature of distal reorientation of the cups seem to be valid generic attributes. Far greater regularity of branching, the presence of distinct cups all of essentially the same shape and size and with definite "food-gathering" surfaces, plus terminal reorientation of the cups in accordance with the development of pendant or recumbent mode of growth, characterize *Titusvillia* but not *Armstrongia*. A comparison of Clarke's (1920) illustration of *Armstrongia* with Mrs. Caster's very careful drawing of *Titusvillia* (Caster, p. 19, fig. 8) brings out these salient differences. In *Armstrongia* we find a diffusion of the characteristics which are standardized in its derivative *Titusvillia*.

Several hundred feet of strata separate the horizons of the Devonian *Armstrongia* and the Mississippian *Titusvillia*. It appears from the occurrence and associated fauna of Clarke's genus and species that the horizon is probably in the Chadakoin stage of the Chautauquan series. Intermediate forms of this sponge are to be anticipated in the

Conewango series of the Upper Devonian, which intervenes between the horizons of the two genera.

During late May, 1939, Mr. Wilson Laird and I examined the section of the Upper Devonian in Northwestern Pennsylvania, and were so fortunate as to discover several specimens of *Armstrongia* and *Titusvillia*. Four specimens of the former genus were discovered in McKean, Erie County, Pa., about ten miles south of Erie, which is essentially the type locality of Armstrong's and Clarke's original material. Additional specimens were found in the old Howard quarry at Howard Falls, Erie County. The horizon is definitely Chadakoin in the vicinity of McKean, and extends into the basa Conewango (Howard Quarry sandstone) at the latter place. *Titusvillia* was found also in the Kushequa shale of the Knapp suite on Yankee Bush Hill, north of Warren, Pa. Several fine specimens were collected, all of which indicate the normal branching described for the genotype. The genus *Titusvillia* is thus far known only from Mississippian strata, and the antecedent genus *Armstrongia* from the Chadakoin and Conewango exclusively.[1] Because of the relative abundance of these fossils, once one grows accustomed to look for them, they proved of considerable stratigraphic value during the recent reconnaissance trip in the Penn-York embayment.

I am extremely grateful to Dr. Butts for calling my attention to my oversight of Clarke's (1920) paper, thus permitting timely discussion of the two genera.

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[1] On July 10, 1939, Mrs. Caster, Mr. Stewart Jones, and I discovered several exquisite specimens of a still earlier representative of the Titusvilliidae in the Enfield shale (Senecan series) of the Upper Devonian in the Hungerford quarry near Cornell University, Ithaca, N.Y. This material, which proves to be generically distinct from both *Armstrongia* and *Titusvillia*, will be the subject of a short analysis in the near future.

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GENOTYPE OF THE AMMONITE GENUS RHACOPHYLLITES

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ABSTRACT—The valid genotype of *Rhacophyllites* is *Ammonites neojurensis* Quenstedt, designated by J. P. Smith in 1927.

THE GENERIC name *Rhacophyllites* Zittel, 1884, is used by some authors for the Liassic ammonites with a modified body chamber, exemplified by "*Rhacophyllites*" *transylvanicus* (Herbich) and "*R.*" *diopsis* (Gemmellaro), whereas others employ Zittel's name for smooth, widely umbilicate Triassic phylloceratids such as *Rhacophyllites neojurensis* (Quenstedt) and *R. debilis* (Hauer).

In a recent article on "the vicissitudes of the genus *Rhacophyllites*," Spath (1939) discusses the divergent usage of the generic name and concludes that "the only fair solution" of the problem would be to ask the International Commission to standardize the genus *Rhacophyllites* with *Rhacophyllites transylvanicus* (Herbich) as genotype. In this article Spath reviews the history of the genus *Rhacophyllites* and contributes much to the better understanding of the genus as a biologic entity, but it seems that most of his arguments are irrelevant to the problem of the conflicting usage of the name *Rhacophyllites*. The problem is primarily one of nomenclature, not of biology.

As it stands today, the problem resolves itself into a critical evaluation of the several genotype designations made at various times by the different authors, and into a selection of the first correctly designated type, which henceforth should stand as the nomenclatural as well as the biological basis of the genus.

After a critical study of the problem I have arrived at the conclusions that the valid genotype of *Rhacophyllites* is *Rhacophyllites neojurensis* (Quenstedt) (=*Ammonites neojurensis* Quenstedt), designated by J. P. Smith (1927), and that this designation according to the Rules (Art. 30, II, g) "is not subject to change."

I have on numerous occasions discussed the problem of *Rhacophyllites* with systematists abroad and in America and, although practically all those who were consulted agreed with my conclusion, there were some who suggested other solutions. Several paleontologists, for example, maintained that *Ammonites eximius* Hauer "designated" by Diener (1908, p. 21) should be regarded as the valid genotype of *Rhacophyllites*. It was even hinted that Dacqué's (1933–34) "type" might be considered. This latter suggestion, however, merits no consideration. Readers familiar with Dacqué's "Wirbellose des Jura" are no doubt aware of the fact that on page 4 of his text Dacqué explicitly states that by "type" he does not mean the type or genotype as generally understood in nomenclature, but merely an example.

In the light of the recent article by Spath, these differences in the interpretation of the problem warrant a restatement of the entire case. It is also felt that some aspects of the problem, particularly those pertaining to Diener's statement of 1908, which were only lightly touched upon by Spath, should be presented more fully, lest the reader get the impression that Diener's "selection" of the type is to be rejected merely because of the use of the more or less ambiguous term "prototype." The reader not familiar with Spath's 1914 paper should also be cautioned not to be misled by the statement which appears at the end of his recent article: "*R. transylvanicus*, Herbich sp. (cited by myself in 1914) as genotype." The reader can prove for himself that in the 1914 article Spath did not cite *transylvanicus* as the genotype of *Rhacophyllites*.

The name *Rhacophyllites* was proposed by Zittel (1884) for the widely umbilicate phylloceratids. Under this genus Zittel listed the

following ten species in the order given: *neojurensis, debilis, occultus, stella, planispira, nardii, transylvanicus, mimatensis, eximius,* and *tortisulcatus.* The written diagnosis of the genus Zittel supplemented by a figure and a drawing of a suture of *Rhacophyllites neojurensis,* together with the suture of *tortisulcatus,* but he did not designate any species as the type of the genus.

To explain the circumstances which caused subsequent confusion in the use of the name *Rhacophyllites,* it should be pointed out that in 1882—two years before the generic name *Rhacophyllites* was proposed by Zittel—Mojsisovics suggested that *Ammonites eximius* together with *A. lariensis, A. rakosensis, A. transylvanicus,* and *A. mimatenis* should be separated from *Phylloceras* as a different genus, and although Mojsisovics did not propose a name for this genus, he nevertheless referred to it as "this new genus."[1]

This statement of Mojsisovics, strictly speaking, has no bearing on the present nomenclatural problem; however, subsequent writers were strongly influenced in their interpretation of Zittel's genus *Rhacophyllites* by this suggestion in 1882 by Mojsisovics. Another reason for bringing this item into the discussion at this time is to enable the reader to evaluate correctly the 1908 statement of Diener which some paleontologists are inclined to accept as the valid designation of *eximius* as the genotype of *Rhacophyllites.*

For the better understanding of the case it should be borne in mind also that, in proposing the new genus *Rhacophyllites,* Zittel in 1884 made no reference to the previously "envisaged" genus of Mojsisovics although three out of five species of Mojsisovics's unnamed "new genus," i.e., *transylvanicus, mimatensis,* and *eximius* were included originally by Zittel among the ten species of his genus *Rhacophyllites.*

As has been already pointed out by Spath (1939), the species listed by Zittel under the genus *Rhacophyllites* represented a heterogeneous group of ammonites, and it was therefore a natural course for subsequent workers, including Geyer (1886, 1893), Pompeckj (1893), Parona and Bonarelli (1895), and Mojsisovics (1896, 1899), to restrict the genus to narrower limits. The name *Rhacophyllites* was thus limited by these authors to the Liassic forms with a modified body chamber, in which scope the genus coincided with the systematic unit outlined but not named by Mojsisovics in 1882.

It is this revision to which Spath (1939, p. 77) refers as "the restriction of *Rhacophyllites* to Mojsisovics's original limits." Although this too has little bearing on the present nomenclatural problem, nevertheless it is hardly admissible to speak of the morphologic limits set forth by Mojsisovics in 1882 as the "original limits" of *Rhacophyllites*—the genus established in 1884 by Zittel. Zittel and Zittel alone is to be accredited with the outlining of the "original" scope of the genus *Rhacophyllites.*

The restriction of the genus *Rhacophyllites,* as reviewed above, would not have resulted in the present confusion had a genotype of the revised genus been designated, and had the widely umbilicate Triassic species been properly taken care of by being assigned to some other genus instead of being left at large. Unfortunately, however, none of these steps was taken by any one of the revisers to insure the nomenclatural stability of the restricted genus.

In 1902 Mojsisovics abandoned the restricted usage of the name *Rhacophyllites* as outlined in the foregoing paragraphs and by applying the name to the widely umbilicate forms such as *neojurensis* and *debilis* reverted to the original interpretation of the genus by Zittel. Mojsisovics, however, also failed to designate a genotype to stabilize the changed concept of the genus and to provide properly for the Liassic forms with a modified body chamber, which he now excluded from the restricted *Rhacophyllites.*

In discussing the genus *Phylloceras,* Diener (1908) stated that

[1] "... Es gehört aber *A. eximius,* an welchen sich *A. lariensis Meneghini* (Fossiles du calcaire rouge ammonitique de Lombardie, pag. 80, pl. XVII, Fig. 1, 2) anschliesst, wohl sicher einer verschiedenen, durch eine abgeänderte Wohnkammer ausgezeichneten Gattung an, in welcher auch *A. rakosensis* Herbich, *A. transylvanicus* Herbich. *A. mimatensis* d'Orb. und einige andere Formen ihren Platz finden werden. Ueber den genetischen Anschluss dieser neuen Gattung an triadische Gattungen vermag ich dermalen noch keine begrundete Vermuthung auszusprechen." —Mojsisovics (1882).

in the paleontological work of E. Mojsisovics three different views have been taken regarding the classification of Triassic species of *Phylloceras*. In 1882 (l.c., p. 151) this learned author advocated the generic separation of *Ammonites eximius* v. Hauer and of *A. lariensis* Menegh. from *Phylloceras* on account of their abnormally shaped body-chamber. In this new genus *A. rakosensis* Herbich, *A. transylvanicus* Herbich, and *A. mimatensis* d'Orb. should be included with *A. eximius* as prototype, but the majority of Triassic species ought to be left with *Phylloceras* s.s.

Let it be understood that the statement just quoted refers to Mojsisovics's "first" of the "three different views" expressed by him in 1882 and later regarding the classification of species of *Phylloceras*.

It is the opinion of some paleontologists that "*eximius* as prototype" in the above quotation from Diener should be construed as the valid designation by Diener of *eximius* as the genotype of *Rhacophyllites*.

I concur with Spath that "the Commission will probably agree that Diener did not make a selection" of the type of *Rhacophyllites*, but in view of the fact that some paleontologists think otherwise it seems warranted to analyze the point more thoroughly.

First, it is pertinent to determine what Diener meant by a "prototype." The term prototype as used by the different authors may mean either the most primitive representative of a group or a primary type (Frizzell, 1933). A critical study of Diener's works reveals that by a "prototype" Diener usually meant a type or genotype.

The ambiguity of the meaning of the term "prototype" thus removed, other evidence will now be presented to show that the statement "*eximius* as prototype" (Diener, 1908) cannot be accepted as Diener's designation of the type of *Rhacophyllites*.

1. The paragraph quoted from Diener is essentially only a restatement (if not a free translation) of Mojsisovics's footnote of 1882, quoted on page 534.

2. In the paragraph quoted, Diener does not mention the name *Rhacophyllites*, which is as it should be, for in 1882—at the time Mojsisovics expressed his "first" view on classification of species of *Phylloceras*—the name *Rhacophyllites* did not exist and by "this new genus" Diener meant the same "new genus" which Mojsisovics envisaged in 1882, but which Mojsisovics did not name and therefore did not establish.

3. That by "this new genus" Diener did not mean *Rhacophyllites* is also evident from his own statement on the preceding page of the same (1908) paper, where, evaluating Zittel's original interpretation of the genus, he states that "*Rhacophyllites* is not at all identical with a group of *Phylloceras* for which E. v. Mojsisovics . . . [in 1882] . . . had claimed a special systematic position."[2]

4. Further proof that the paragraph containing the words "*eximius* as prototype" does not represent Diener's own idea but is only a restatement of Mojsisovics's view expressed in 1882 is suggested by the concluding words that "the majority of Triassic species ought to be left with *Phylloceras* s.s." This is certainly not the view which Diener held in 1908 with regard to the Triassic phylloceratids.

5. And finally, as has been already pointed out by Spath (1939, p. 79), Diener in 1908 (pages 76–80) actually adopted the name *Rhacophyllites* for Liassic phylloceratids with an abnormal body chamber as in *transylvanicus*, *diopsis* and related species. From Diener's own text there is not a slightest suggestion that he intended to designate *eximius* as the type of *Rhacophyllites*.

From the foregoing discussion it may be concluded that the 1908 statement of Diener "rigidly construed" does not constitute the designation of *eximius* as the type of *Rhacophyllites*.

In discussing this problem Spath (1939, p. 79) alleges that Diener in 1908 "inci-

[2] "K. von Zittel (Handbuch der Paleontologie II, p. 439) proposed the new subgenus (or genus) *Rhacophyllites* for the accommodation of such species of *Phylloceras* as are distinguished by wide umbilici, by a steep umbilical slope, and by a smaller number of auxiliary lobes than are noticed in typical species of *Phylloceras*. In this interpretation *Rhacophyllites* comprises species of Triassic, Liassic and even Jurassic age (*Phyll. tortisulcatum* d'Orb.) and is not at all identical with a group of *Phylloceras* for which E. v. Mojsisovics (Cephalopoden der Mediterranen Triasprovinz, Abhandl. K. K. Geol. Reichsanst, X, p. 151) had claimed a special systematic position, chiefly on account of its body chamber differing materially from the chambered portion of the shell, and on account of a special arrangement of the auxiliary series, which is united into a sloping suspensive lobe."—(Diener, *1908*, p. 20.)

dentally spoke of *Amm. eximius* (Hauer) as the 'prototype' of the 'new genus' *Rhacophyllites*." This statement is misleading. In Diener's 1908 paper the words "new genus" and the name *Rhacophyllites* do not occur in a single sentence as one may be led to believe from Spath's text. Similarly misleading is Spath's statement on the same page that

> since I quoted from Diener's 1908 paper, it is clear that the mention of *R. eximius* as the "prototype" of *Rhacophyllites* (in Diener) did not appear to me to be a "selection."

Had there been such a statement in Diener's 1908 paper one possibly could have made a fair case for validating this "selection," but, may it be repeated again that nowhere in Diener's paper is there such an expression as "*eximius* as the 'prototype' of *Rhacophyllites*."

In 1911 Jullien established two new genera, *Diphyllites* and *Triphyllites*, and as their types he named *Phylloceras neojurense* Quenstedt and *Phylloceras debile* Hauer respectively. Both of these species had been originally included by Zittel under his genus *Rhacophyllites*. Their separation by Jullien as types of new genera, however, contrary to the opinion recently expressed by Spath, does not eliminate them as possible types of *Rhacophyllites*, as long as the latter remains without any type designated for it.

In 1914 Spath renewed the discussion of *Rhacophyllites*, once more recommending the restriction of the genus to "the ornamented forms, preferably the *transylvanicus-diopsis* group" but did not designate the type until 1923, when he chose as the "lectotype" *Phylloceras diopsis* Gemmellaro. According to the Rules, however, (Art. 30, II, e, α) the species *diopsis* is excluded from consideration in determining the type of the genus *Rhacophyllites*, as it was not included under the generic name at the time of its original publication. Spath's designation is, therefore, not valid.

In 1927 J. P. Smith designated *Ammonites neojurensis* Quenstedt as the type of *Rhacophyllites*. As has been stated above, the species *neojurensis* had been in 1911 designated by Jullien as the genotype of *Diphyllites*, but this fact, contrary to the opinion of Spath, does not invalidate Smith's designation. The Commission on the International Rules in passing a ruling on a similar, if not identical, case (Opinion 62) held that "type species of other genera are not excluded from consideration in the selection of the type of the genus." Arguments put forth by Spath against accepting Smith's designation of *neojurensis* as the type of *Rhacophyllites* can be best met by quoting further from Opinion 62.

> . . . Whether the author designating a species as type does so in ignorance of previous action of others or without knowledge of the previous literature, or any similar reason, whether he does so rightly or erroneously as we may individually view the case, if he avoids the three classes enumerated under α, β, and γ [of the Article 30], his "designation is not subject to change," either by himself or others. To accept another view would be likely to endanger the stability of generic names, for if it should be found in the future that the species which it is now supposed the designator *ought* to have designated, also had been selected by a now unknown author as the type of a now unknown genus, the designation of a type of the original genus would have to be done over again, and would consequently be subject to change. Article 30 was framed in order to prevent the shifting of types once designated. . . . The fear that the . . . view (as held by the Commission) would cause changes in current nomenclature can have no influence on reaching an objective conclusion. When Art. 30 was proposed and adopted it was well known that it would make a number of such changes necessary, but so would any other rule which could possibly be framed.

In view of the foregoing, Smith's designation of *neojurensis* as the type of *Rhacophyllites* is the first valid designation, which "is not subject to change" and must therefore stand. Jullien's genus *Diphyllites* automatically falls into synonymy under *Rhacophyllites* and, incidentally, so does also Jullien's genus *Triphyllites*, for, as has been already pointed out by Spath (1934), the morphologic differences between the two genera of Jullien are of not more than specific value.

The Liassic species with a modified body chamber previously included by some authors in "*Rhacophyllites*" are now left without a generic name. For these ornate Jurassic phylloceratids a new name *Juraphyllites* Muller, n. gen., is here proposed, with the genotype *Phylloceras diopsis* Gemmellaro (1884). It is realized that this action is in no way connected with the nomenclatural problem of *Rhacophyllites* but it was

felt advisable to make this provision so as to eliminate the confusion likely to arise in the future from the incorrect application of the name *Rhacophyllites*.

With the establishment of *neojurensis* as the valid genotype of *Rhacophyllites*, all subsequent discussion of the subject may be dismissed. However, it may be of passing interest to note that Arthaber (1928), independently of Smith, also selected *neojurensis* as the genotype of *Rhacophyllites*. On the other hand, Spath (1927) again cited *diopsis* as the genotype of *Rhacophyllites* and in this he was followed by Roman (1938).

This report is a part of the investigation in progress under the auspices of the U. S. Geological Survey and aided by a grant from the Penrose Bequest of the Geological Society of America.

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JOURNAL OF PALEONTOLOGY, VOL. 13, NO. 5, P. 538, SEPTEMBER, 1939

OPERCULINA BARKERI, NEW NAME FOR O. TUBERCULATA VAUGHAN AND COLE, 1936

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IN THE recently published "Bibliography and index to new genera, species, and varieties of Foraminifera for the year 1936" Thalmann (1939, pp. 426–459) noted that the specific name *tuberculata*, applied by us (1936, pp. 488–489) to a species of *Operculina* from the Eocene of Mexico, was preoccupied by *O. costata* d'Orbigny var. *tuberculata* Douvillé (1911, p. 56). Although Barker (1939, pp. 319–320) has stated that he thinks that this species should be referred to the genus *Operculinoides*, it is still our opinion that it is a representative of the genus *Operculina*. Therefore, the name *Operculina barkeri*, in honor of R. Wright Barker, who has done outstanding work on Mexican Foraminifera, is proposed instead of *Operculina tuberculata*, preoccupied.

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REVIEWS

PREHISTORIC LIFE. By Percy E. Raymond, Professor of Paleontology, Harvard University. Cambridge: Harvard University Press, 1939. Pp. xi+324; figs. 156.

Professor Raymond's new book is a fortunate appearance in print of his lectures in introductory paleontology at Harvard University. The author's scientific standing, his method, his level-headed philosophy, his ability to bring out the most interesting aspects of a subject which can be dry, and last but not least his occasional and always very appropriate brief sallies in whimsical humor, make the book an outstanding one in its field. The modesty and plain frankness of the author—reflected in his style—is illustrated by the following passage from the Introduction (p. viii): "When I came to Harvard in 1912, I knew nothing about paleontology, although I had held responsible positions as paleontologist previously, and was recognized as an 'authority' in my particular field. When I found I was expected to teach the subject, I set out to learn something about it. As my education progressed, I found that I could best interest students by telling them of the things which most interested me."

The manner of treatment of the subject adopted by Professor Raymond is logical and agreeable from the reader's standpoint. The orthodox arrangement of chapters on presumably more and more advanced or complex phyla has been varied here and there by a sequence of subject matter which tends to hold the interest of the reader and stimulate his desire to read the next chapter before he pauses. The first five chapters are: I, Fossils; II, Collecting Fossils; III, The

First Animals and Plants; IV, Pre-Cambrian Life; V, the Ordovician Fauna. Each chapter is authoritative yet delightful reading. For example, the description of the technique of collecting vertebrate fossils included in Chapter II is thoroughly interesting. The discussion of the theories advanced to account for the lack of pre-Cambrian fossils in Chapter IV is interesting and good food for thought. From Chapter V Dr. Raymond goes to Trilobites—members of a phylum of highly organized animals on which the author is a leading authority. The history of vertebrates from the primitive cordates through fish to the amphibia, then the reptiles, "From Scales to Feathers" (Chapt. XVIII), and finally the chapters on mammals, present an evolutionary picture with occasional special treatment of some related but nonphylogenetic matter such as "The Importance of Plants" (Chapt. XXVIII).

The book presents "the general results of the work of hundreds of paleontologists, not specific details." Its value lies not only in the picture of evolution it presents and the "history of life from the time of its first appearance on the earth to the present," but also in the discussion and illustration of the effect of the physical environment on the direction of successful evolution.

Footnotes and a bibliography have been entirely omitted. This is somewhat unusual and may be regretted by some readers. To the reviewer the lack of these distractions was refreshing.

Pedagogically, the reviewer agrees with Professor Raymond's theory of education as briefly stated by him and as illustrated in the breadth of viewpoint which characterizes the book. He states (p. viii): "Theoretically, education should proceed from the general to the special. That, however, is not the tradition in paleontology. Most paleontologists started as collectors of fossils. . . . Many never progressed beyond this stage. . . . His own experience . . . convinces him that the broader the background, the better the specialist." This reviewer, being a relatively unknown teacher of paleontology, has recognized the error of "educational short cuts" and premature specialization, and he appreciates the value of a foundation of fundamental principles. Raymond's "Prehistoric Life" is recommended to specialists in limited fields of paleontology as well as to the beginner and the general scientific reader. A good specialist should have a broader background knowledge of the general field than can be obtained from an intensive study of one narrow field. "Prehistoric Life" offers an easy means of gaining some of this broadening.

U. S. GRANT

NOMENCLATOR ZOOLOGICUS, a list of the names of genera and subgenera in zoology from the tenth edition of Linnaeus 1758 to the end of 1935, edited by Sheffield Airey Neave. Published by the Zoological Society of London.

Announcement is made of the publication of Vol. 1, A—C (pp. xiv+958). The remaining three volumes, which will be of approximately the same size, will appear at intervals of about six months. The price of the complete work, bound in buckram, is 8 guineas, post free. Subscriptions should be sent to the Zoological Society of London, Regent's Park, London, N.W. 8, England. The scope of the work is indicated by the following sample entries:

Billingsia Koninck 1877, Mém. Soc. Sci. Liége, (2) **6**, Rech. Foss. Paléoz., 75.—Coel.
Billingsia Walcott 1886, Bull. U. S. Geol. Surv., No. 30, 21, 60 [*n.n.*]; Miller 1889, No. Amer. Geol. Palaeont., 398.—Moll.
Billingsia Ford 1886, Amer. J. Sci., (3) **31**, 466.—Brach. (See *Elkania* Ford 1886.)

IGNAZ LICHTIG, *Die Enstehung des Lebens durch stetige Schöpfung* [*The origin of life by constant creation*]. 6 Gulden (paper), 7.50 Gulden (bound). Amsterdam, N. V., Noord-Hollandsche Uitgeners Maatschappij, 1938.

With our constantly increasing detailed knowledge of faunas and floras, both fossil and recent, as well as through our more intimate insight into the comparative morphology and relationships within and between the groups of organisms, the seeming simplicity and straightforwardness attributed to the evolutionary progress of living matter by Lamarck, Darwin, and their contemporaries and successors have become increasingly illusory and obscure.

The great number of facts that are at apparent variance to the generally accepted monophyletic ascent and monogenetic origin of life have led investigators to erect so many explanatory hypotheses that the whole theory has been materially weakened. Stimulated by these facts, the author has attacked this problem from a basically philosophical standpoint, marshalling, however, to his side innumerable facts that he has gathered during years of study and reading in the biological sciences.

In this book he attacks the two basic problems: that of the origin of life and that of the evolution of life. Of the first one he says that life is constantly and slowly being created independently everywhere and in many forms, basing his theory principally on rationalistic philosophical arguments.

Matter may be divided into various stages of complexity, from the simplest electronic unit to the highest mammalian organism. The world is dynamic and constantly changing, and in matter this reveals itself as a constant rise from a lower to a higher stage of complexity. The reverse also takes place, much more rapidly, in the processes of death and disintegration. The author considers the change from abiotic to biotic life as merely one link in this constant evolution, or, as he terms it, "complication" (Verwickelung). He shows how fine is the borderline between lifeless and living matter, citing the vira and other ultramicroscopic life as examples. The basic active agent in evolution Dr. Lichtig believes to be the effect of the environment in the broad sense, which, when it has acted long enough, causes an inheritable change.

The commonly held theory of monophyletic evolution the author, furthermore, replaces by a polyphyletic system, as a necessary consequence of his constant-creation theory. If life is being continually created there must be innumerable rows of ascending evolutionary lines in different stages going on today. This explains why we have living today examples of organisms of all forms of complexity, from the protozoa and bacteria to mammals; they are contemporaneous stages of evolutionary lines that have arisen at various times, the more primitive organisms being from younger lines, more recently risen from the abiotic, while the higher groups represent more ancient lineages.

To support his polyphyletic theory, he adduces facts from various branches of biology, with each of which he deals in a separate chapter.

In morphology and systematics the absence of intermediate types and the presence of isolated groups present insurmountable difficulties in the way of a monophyletic view. Especially is this the case with the phenomenon of "cross specialization," wherein one form is more highly organized than another organism in one or more particulars, but less highly organized in other characteristics. Completely different classifications may be evolved according to the characters used for comparison and differentiation.

In ontogeny we often find that similar stages in the ontogeny of two organisms cannot be approximated because the adult stages of the same two organisms cannot be related. The reverse is also true; morphologically similar forms may have a totally different ontogeny.

In paleontology the phenomena of sudden efflorescences of certain groups at certain periods and that of "geological intermezzos" —by which is meant the apparent absence of certain groups during shorter or longer periods, only to reappear later—can best be explained, according to the author, by a polyphyletic theory. The Tunicata and the Acrania are not known in the fossil state, an example of primitive groups appearing later geologically than more advanced groups. As we go back geologically the author says, we would expect to find the different phyla becoming fewer until only the most primitive ones are left, but in the Cambrian we have all phyla present except the Vertebrates and the land plants.

In phylogeny, in order to maintain the monophyletic theory, there have been, according to the author, too many hypotheses adopted, that of degeneration, for instance, and certain workers have been too prone to invent hypothetical intermediate forms, imaginary ancestors, which combine the characters of their divergent descendents. It has been generally assumed that certain characters have indeed arisen polyphyletically, and this the author considers

a body blow to the monophyletic theory as a whole. Such characters are gymnospermy among plants, and among animals the highly organized eye in Cephalopods and vertebrates. Dr. Lichtig says that the polyphyletic theory is merely the drawing to an ultimate logical conclusion of tendencies that the monphyletic theory has gradually had to adopt, when forced more and more to give up the conception of a single evolutionary line in favor of hypothetical common ancestors.

The author cites many cases of convergence of characters which must have arisen polyphyletically. A great many of these cases are due to the organisms inhabiting similar environment. This leads to the conclusion that form relationship and genetic relationship are different. What is genetically related is also morphologically related, but the reverse of this is not true. It is impossible to combine a systematic classification, which is based on form, with a phylogenetic classification, based on genetic relationship.

In the chapter on the stratigraphical argument he states that formations bearing similar faunas can be considered isochronous only if one accepts the theory of constant ubiquitous creation, for the monophyletic view would necessitate a long-time migration that would destroy the isochronous concept. That is, he suggests that formations may be isochronous and not homotaxial or homotaxial and not isochronous, but not both. Here I think the author has not taken into sufficient consideration the length of time involved in one of these formations, and also the fact that these formations are not so similar as to preclude parallel development from more ancient ancestors. Under the monophyletic theory the *Semicassis sulcosa* Bruguière of the Mediterranean is not necessarily considered directly descended or even directly related to the Antillean *Semicassis granulatum* Born; they are more likely descendents of ancestors that were once directly related or identical.

In the sphere of biogeography the author claims that only through the creation of life everywhere can the distribution of organisms be explained. Discontinuous distribution, according to him, is not satisfactorily interpreted by the relict theory, or by land bridges, or by the continental drift theory. To this reviewer it seems more logical to base our distributional ideas on a modified combination of the latter concepts rather than on the ubiquitous origin of life, for it would then still have to be explained why similar organisms arose in areas comparatively close, rather than in more distant areas where they might just as well have arisen if it were a matter of chance alone.

The author has pointed out the weaknesses of our generally accepted theories of the origin of life and evolution, and has very logically built up a theory to surmount these difficulties. It is a question whether in the process he has not come upon other difficulties equally disturbing. To explain the independent origin of morphologically similar forms, he apparently relies on the chance combination of similar characters, acted upon by a similar environment. To the reviewer this seems to leave too much to the factor of chance. The facts of geographic distribution are not easily explainable on this basis.

Dr. Lichtig has done an invaluable piece of work that it is hoped will call attention to the peculiar problems connected with the more theoretical aspects of biology. It is for this reason that it is hoped an English translation of this book may appear in the near future, to make more readily available to American workers this philosophical attack on biology's most vexing problems.

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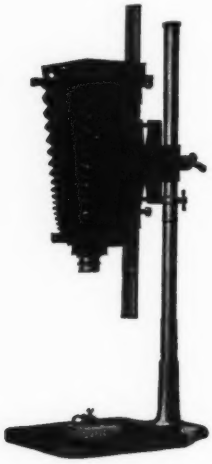

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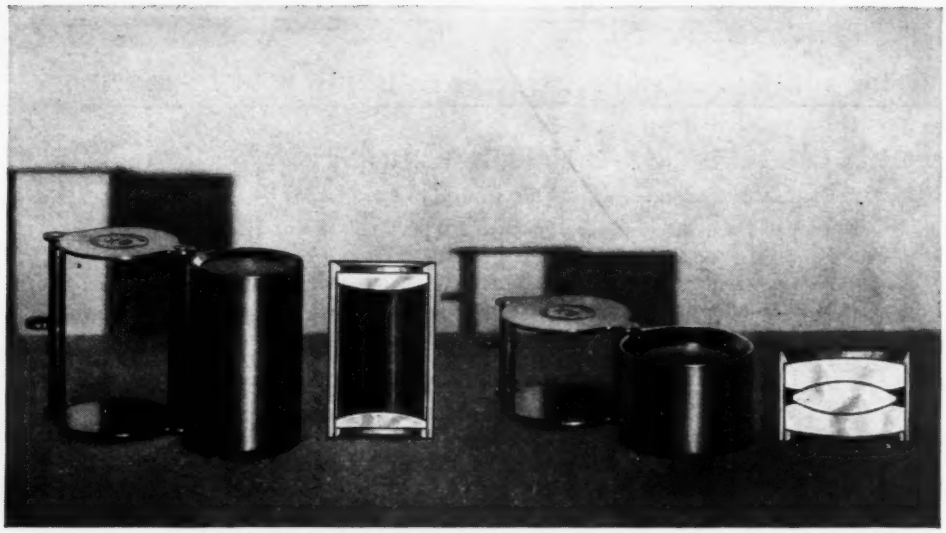

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